TGFβ SUPPORTED AND BINDING PEPTIDES

The present application claims priority under 35 U.S.C. §119, to co-pending U.S. Provisional Patent Application Serial Number 60/518,154, filed November 6, 2003, co-pending U.S. Provisional Patent Application Serial Number 60/520,403, filed November 13, 2003, co-pending U.S. Provisional Patent Application Serial Number 60/530,954, filed December 19, 2003, co-pending U.S. Provisional Patent Application Serial Number 60/531,207, filed December 19, 2003, and co-pending U.S. Provisional Patent Application Serial Number 60/531,189, filed December 19, 2003.

Field of the Invention

The present invention provides peptides and supported peptides that bind TGFβ molecules. In some particularly preferred embodiments, the TGFβ binding molecules bind TGFβ-1, while in other embodiments, the TGFβ binding molecules bind TGFβ-2.

Background of the Invention

Proteins of the Transforming Growth Factor-β (TGFβ) family are synthesized by almost all cells. The TGFβs are a group of stable, multifunctional polypeptide growth factors whose activities include, among other things, context-specific inhibition and stimulation of cell proliferation, control of the extracellular matrix, degradation and control of mesenchymal-epithelial interactions during embryogenesis, mediation of cell and tissue responses to injury, control of carcinogenesis and modulation of immune responses. Structurally, each TGFβ monomer consists of two anti-parallel pairs of β strands which form a flat curved surface, a separate long alpha-helix and a disulfide-rich core with a cysteine knot (*See e.g.,* Daopin and Davies, Proteins, Structure Function and Genetics, 17:176-192 [1993]; and Daopin *et al.*, Science, 257:369-373 [1992]; and Daopin *et al.*, Science, 258:1160-1162 [1992]). These growth factors are secreted as latent pro-TGFβs, and the C-terminal is cleaved by a subtilisin-like pro-protein convertase protease to form TGFβ. Most TGFβs form disulfide-linked homodimers and signal via serine/threonine receptor complexes.

TGFβ-1 is synthesized by virtually all cells (with only a few exceptions). TGFβ-1 has been found in the highest concentration in human platelets and mammalian bone. TGFβ-1 has many functions including suppression of cell proliferation, enhancement of extracellular matrix deposition and physiological immunosuppression. TGFβ-1 has also been determined to be biologically active in hair follicle development. Human TGFβ-1 is a 25.0 kDa protein with

subunits that contain approximately 112 amino acids per subunit. Two different receptor proteins are involved in TGFβ-1 binding and signaling, namely TGF-RβII and TGF-RβI.

TGFβ-2 is expressed in a variety of cells, including keratinocytes, fibroblasts, osteoclasts, thymic epithelium, skeletal muscle cells, prostatic epithelium, bronchial epithelium, neurons and astrocytes, visceral smooth muscle, macrophages and various other cells. TGFβ-2 has many fundamental activities, including function as a growth inhibitor for most cells, an enhancer for deposition of the extracellular matrix, and immunosuppression. The mature region is 71% identical to TGFβ-1, 80% identical to TGFβ-3, and 97% identical to the mouse homologue of the same protein at the amino acid level. TGFβ-2 dimerizes with formation of disulfide bonds between the 'pro' regions and disulfide bonds between the mature regions. TGFβ-2 is synthesized as a pre-procytokine with a 19 amino acid signal sequence, a 283 pro-region and a 112 mature amino acid segment. The receptor for TGFβ-2 forms a heterotetrameric complex of two type I signal-transduction receptors and two type II ligand-binding receptors.

The Bowman-Birk protease inhibitor (BBI) is a designation of a family of stable, low molecular weight trypsin and chymotrypsin enzyme inhibitors found in soybeans and various other seeds, mainly leguminous seeds and vegetable materials. BBI comprises a family of disulfide bonded proteins with a molecular weight of about 8 kD (*See e.g.*, Chou *et al.*, Proc. Natl. Acad. Sci. USA 71:1748-1752 [1974]; Yavelow *et al.*, Proc. Natl. Acad. Sci. USA 82:5395-5399 [1985]; and Yavelow *et al.*, Cancer Res. (Suppl.) 43:2454s-2459s [1983]). BBI has a pseudo-symmetrical structure of two tricyclic domains each containing an independent native binding loop, the native loops containing binding sites for both trypsin and chymotrypsin (*See*, Liener, *in* Summerfield and Bunting (eds), Advances in Legume Science, Royal Bot. Gardens, Kew, England). These binding sites each have a canonical loop structure, which is a motif found in a variety of serine proteinase inhibitors (Bode and Huber, Eur. J. Biochem., 204:433-451 [1992]). Commonly, as in one of the soybean inhibitors, one of the native loops inhibits trypsin and the other inhibits chymotrypsin (See, Chen *et al.*, J. Biol. Chem., 267:1990-1994 [1992]; Werner & Wemmer, Biochem., 31:999-1010 [1992]; Lin *et al.*, Eur. J. Biochem., 212:549-555 [1993]; and Voss *et al.*, Eur. J. Biochem., 242:122-131 [1996]) though in other organisms (*e.g.*, *Arabidopsis*), both loops are specific for trypsin.

STI inhibits the proteolytic activity of trypsin by the formation of a stable stoichiometric complex (*See e.g.*, Liu, Chemistry and Nutritional Value of Soybean Components, *In:* Soybeans, Chemistry, Technology and Utilization, pp. 32-35, Aspen Publishers, Inc., Gaithersburg, Md., [1999]). STI consists of 181 amino acid residues with two disulfide bridges and is roughly spherically shaped (*See e.g.*, Song *et al.*, J. Mol. Biol., 275:347-63 [1998]). The trypsin inhibitory loop lies within the first disulfide bridge. The Kunitz-type soybean trypsin inhibitor

(STI) has played a key role in the early study of proteinases, having been used as the main substrate in the biochemical and kinetic work that led to the definition of the standard mechanism of action of proteinase inhibitors.

Eglin C is a small monomeric protein that belongs to the potato chymotrypsin inhibitor family of serine protease inhibitors. The proteins that belong to this family are usually small (60-90 amino acid residues in length) and contain no disulfide bonds. Eglin C, however, is highly resistant to denaturation by acidification or heat regardless of the lack of disulfide bonds to help stabilize its tertiary structure. The protein occurs naturally in the leech *Hirudo medicinalis*.

Formation of hair follicles involves a complex series of steps: growth (anagen), regression (catagen), rest (telogen) and shedding (exogen) (*See*, Stenn and Paus, Physiol. Rev, Exp. Dermatol., 8:229-233 [1999]). TGFβs have been implicated as one of the major drivers of the transition from anagen to catagen in the hair cycle (*See e.g.*, Foitzik *et al*, FASEB J., 5:752-760 [2000]; and Soma *et al.* J. Infect. Dis., J. Invest. Dermatol., 118:993-9997 [2002]), and TGFβ2 is both a required and sufficient inducer of murine hair follicle morphogenesis (*See*, Foitzik *et al.*, Develop. Biol., 212:278-289 [1999]). Conditional TGFβ-1 expression in transgenic mice demonstrates that one can induce alopecia reversibly (*See,* Liu *et al.*, Proc. Natl. Acad. Sci. USA 98:9139-9144 [2001]). In addition, TGFβ-1 mutants have been associated with the delay of catagen onset in mice (*See,* Foitzik *et al*, [2000], *supra*). Recently, it has been shown that catagen can be delayed through the use of TGFβ-2 antibodies (*See*, Soma *et al.*, [2002], *supra*). Finally, androgens that induce TGFβ-1 production in balding dermal papilla cells can inhibit epithelial cell growth (Inui *et al.*, FASEB J., 14:1967-1969 [2002]).

Summary of the Invention

The present invention provides peptides and supported peptides that bind TGFβ molecules. In some particularly preferred embodiments, the TGFβ binding molecules bind TGFβ-1, while in other embodiments, the TGFβ binding molecules bind TGFβ-2. In some preferred embodiments, the present invention provides further cosmetic and/or pharmaceutical compounds suitable for modulating hair growth.

In some embodiments, the present invention provides peptides that bind and block binding of TGFβ-1 or TGFβ-2, wherein the peptide is expressed in a protease-resistant scaffold. In some preferred embodiments, the scaffold is a protease inhibitor (*e.g.*, BBI, STI, or Eglin chymotrypsin inhibitor).

The present invention provides compositions comprising at least one peptide selected from the group consisting of SEQ ID NOS:2, 4, 6, 8, 10, 12, 14, and 16, wherein said peptide binds to a transforming growth factor. In some alternative embodiments, the peptide is encoded

by a nucleic acid sequence selected from the group consisting of SEQ ID NOS:1, 3, 5, 7, 9, 11, 13, and 15. In some preferred embodiments, the peptide is expressed in a protease resistant scaffold. In still further embodiments, the scaffold is a protease inhibitor. In some particularly preferred embodiments, the protease inhibitor is selected from the group consisting of Bowman-Birk Inhibitor, soybean trypsin inhibitor, and Eglin chymotrypsin inhibitor. In alternative preferred embodiments, the protease resistant scaffold and the peptide comprise a fusion protein.

The present invention also provides cosmetic and/or pharmaceutical compositions comprising said at least one peptide that binds to a transforming growth factor. In some embodiments, the composition is capable of modulating hair growth. In some preferred embodiments, the composition further comprises a scaffold.

The present invention also provides methods for modulating hair growth comprising: i) providing a composition comprising a peptide contained within a scaffold; ii) providing a subject to be treated; and iii) applying the composition to the subject in an area in which hair growth modulation is desired. In some embodiments, the peptide binds to a transforming growth factor-beta (TGFβ). In alternative embodiments, the TGFβ is selected from the group consisting of TGFβ-1 and TGFβ-2. In further embodiments, the scaffold is selected from the group consisting of Bowman-Birk inhibitor, soybean trypsin inhibitor, and Eglin chymotrypsin inhibitor. In still further embodiments, the peptide is selected from the group consisting of SEQ ID NOS: 2, 4, 6, 8, 10, 12, 14, and 16. In some embodiments, the peptide is encoded by a nucleic acid sequence selected from the group consisting of SEQ ID NOS:1, 3, 5, 7, 9, 11, 13, and 15.

The present invention also provides methods for decreasing the activity of a transforming growth factor comprising the steps of: i) providing a subject; and ii) administering a composition comprising at least one peptide that binds to a TGFβ to said subject, under conditions such that the activity of the transforming growth factor is decreased. In some embodiments, the transforming growth factor is selected from the group consisting of TGFβ-1 and TGFβ-2.

The present invention also provides compositions comprising at least one TGFβ-1 peptide sequence selected from the group of SEQ ID NOS:2, 4, 6, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, and 34.

The present invention also provides compositions comprising at least one TGFβ-2 peptide sequence selected from the group of SEQ ID NOS:8, 10, 12, 14, and 16.

In some preferred embodiments, the present invention provides cosmetic and/or pharmaceutical compounds for modulating hair growth comprising at least one polypeptide and/or peptide. In some particularly preferred embodiments, the compound comprises at least one polypeptide.

In alternative preferred embodiments, the compound comprises at least one peptide. In some preferred embodiments, the peptide has an amino acid sequence selected from the group consisting of SEQ ID NOS:2, 4, and 6 (*See*, Table 1). In a preferred embodiment, the compound has a sequence, the sequence being at least 70%, preferably 80%, preferably 90%, preferably 95% homologous to the sequences set forth herein. In a preferred embodiment, the polypeptide has a molecular weight that is preferably between 500 Daltons and 30,000 Daltons, preferably between 1000 Daltons and 10,000 Daltons, and more preferably between 1500 Daltons to 8,000 Daltons.

In alternative preferred embodiments, the compound comprises at least one peptide. In some preferred embodiments, the peptide has an amino acid sequence selected from the group consisting of SEQ ID NOS:8, 10, 12, 14, and 16 (*See*, Table 2). In a preferred embodiment, the compound has a sequence, the sequence being at least 70%, preferably 80%, preferably 90%, preferably 95% homologous to the sequences set forth herein. In a preferred embodiment, the polypeptide has a molecular weight that is preferably between 500 Daltons and 30,000 Daltons, preferably between 1000 Daltons and 10,000 Daltons, and more preferably between 1500 Daltons to 8,000 Daltons.

In some preferred embodiments, modulation of hair growth/development comprises treatment of at least one disease or condition that involves loss of hair. In some preferred embodiments, the disease or condition is at least one selected from the group consisting of inflammatory alopecias, pseudopelade, scleroderma, tick bites, lichen planus, psoriasis, lupus, seborrheic dermatitis, loose hair syndrome, hemochromatosis, androgenic alopecia, alopecia areata, cancer, conditions that affect defective hair fiber production and environmental factors that affect hair production. In a preferred embodiment, the disease is androgenic alopecia or alopecia areata.

In some preferred embodiments, modulation comprises inhibition of hair growth and/or hair removal for treatment of at least one disease or condition for which hair growth is undesirable. In some preferred embodiments, the hair growth inhibition and/or hair removal comprises depilation.

In further embodiments of the present invention, cosmetics and pharmaceutical compounds for modulating hair growth comprising a peptide or a polypeptide and a scaffold, the peptide or polypeptide sequence being contained in the scaffold, preferably the peptide or polypeptide being a loop, preferably, the loop being closed by a disulfide bond are provided. In some embodiments, the peptide or polypeptide binds to TGFβ-1 and blocks its downstream activity, while in other embodiments, the peptide or polypeptide binds to TGFβ-2 and blocks its downstream activity. In some preferred embodiments, the scaffold is STI, while in others it is

Eglin, and in still others it is BBI. In some most preferred embodiments, the preferred scaffold is BBI. In further preferred embodiments, the compound is a polypeptide.

In additional preferred embodiments, the compound is a peptide. In some particularly preferred embodiments, the peptide has an amino acid sequence selected from the group consisting of SEQ ID NOS:2, 4, and 6 (*See*, Table 1). In some alternative particularly preferred embodiments, the peptide has an amino acid sequence selected from the group consisting of SEQ ID NOS:8, 10, 12, 14, and 16 (*See*, Table 2). In some preferred embodiments, the compound comprises an amino acid sequence, wherein the sequence is at least 70%, preferably 80%, more preferably 90%, and most preferably 95% homologous to the sequences set forth herein. In some preferred embodiments, the polypeptide has a molecular weight that is between 500 Daltons and 100,000 Daltons, more preferably between 500 Daltons and 45,000 Daltons, even more preferably between 1000 Daltons and 12,000 Daltons, and most preferably between 1500 Daltons to 10,000 Daltons.

In some preferred embodiments, modulation utilizing the peptides of the present invention comprises treatment of at least one disease or condition that involves loss of hair. In a preferred embodiment, the disease or condition is at least one selected from the group consisting of inflammatory alopecias, pseudopelade, scleroderma, tick bites, lichen planus, psoriasis, lupus, seborrheic dermatitis, loose hair syndrome, hemochromatosis, androgenic alopecia, alopecia areata, cancer, conditions that affect defective hair fiber production and environmental factors that affect hair production. In some preferred embodiments, the disease is androgenic alopecia or alopecia areata.

In some preferred embodiments, the modulation provided by the compositions of the present invention comprises inhibition of hair growth, while in other embodiments, modulation is accomplished via hair removal. In particularly preferred embodiments, this modulation is used for treatment of at least one disease or condition for which hair growth would not be desirable. In some preferred embodiments, the hair growth inhibition and/or hair removal comprises depilation.

In yet further embodiments, the present invention provides cosmetic and/or pharmaceutical compositions comprising a polypeptide or peptide, as set forth herein, and a physiologically acceptable carrier or excipient. Preferably, the compound is present in an amount of about 0.0001% to about 5% by weight based on the total weight of the composition. Also preferably, the compound is present in an amount of about 0.001% to about 0.5% by weight based on the total weight of the composition. The composition may be in the form of an emulsified vehicle, such as a nutrient cream or lotion, a stabilized gel or dispersion system, a treatment serum, a liposomal delivery system, a topical pack or mask, a surfactant-based cleansing system such as a shampoo or body wash, an aerosolized or sprayed dispersion or

emulsion, a hair or skin conditioner, styling aid, or a pigmented product such as makeup, as well as other suitable make-up and cosmetic preparations. In some embodiments, the carrier is preferably at least one selected from the group consisting of water, propylene glycol, ethanol, propanol, glycerol, butylene glycol and polyethylene glycol.

In yet further embodiments, the present invention provides means for decreasing TGFβ-1 and/or TGFβ-2 activity(ies). In some embodiments, the method comprising applying an effective amount of at least one of the compounds described herein to an organism in need thereof.

In additional embodiments, the present invention provides applications for hair and/or skin treatment, as well as applications wound healing, treatment of proliferative diseases, etc. Thus, the present invention provides compositions and methods suitable for application in/on humans and other animals.

Description of the Figures

Figure 1A provides the plasmid map for pME30.16.

Figure 1B provides the plasmid map for p2JM103-DNNDPI-BBI;.

Figure 1C provides the plasmid map for pCB04.

Figure 2 provides the amino acid sequence of BBI backbone used herein comprising approximately 71 amino acid residues. The loops are underlined.

Figure 3 provides the first screen data, BLA activity plotted against total BLA activity for TGFβ-1. The x-axis provides the total BLA activity and the Y-axis provides bound BLA activity, as described in the Examples.

Figure 4 provides the first screen data, BLA activity plotted against total BLA activity for TGFβ-2. The x-axis provides total BLA activity and the Y-axis provides bound BLA activity, as described in the Examples.

Description of the Invention

Unless otherwise indicated, the practice of the present invention involves conventional techniques commonly used in molecular biology, microbiology, and recombinant DNA, which are within the skill of the art. Such techniques are known to those of skill in the art and are described in numerous texts and reference works (See e.g., Sambrook *et al.*, "Molecular Cloning: A Laboratory Manual", Second Edition (Cold Spring Harbor), [1989]); and Ausubel *et al.*, "Current Protocols in Molecular Biology" [1987]). All patents, patent applications, articles and publications mentioned herein, both *supra* and *infra*, are hereby expressly incorporated herein by reference.

Unless defined otherwise herein, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention

pertains. For example, Singleton and Sainsbury, *Dictionary of Microbiology and Molecular Biology*, 2d Ed., John Wiley and Sons, NY (1994); and Hale and Marham, *The Harper Collins Dictionary of Biology*, Harper Perennial, NY (1991) provide those of skill in the art with a general dictionaries of many of the terms used in the invention. Although any methods and materials similar or equivalent to those described herein find use in the practice of the present invention, the preferred methods and materials are described herein. Accordingly, the terms defined immediately below are more fully described by reference to the Specification as a whole. Also, as used herein, the singular "a," "an," and "the" includes the plural reference unless the context clearly indicates otherwise. Numeric ranges are inclusive of the numbers defining the range. Unless otherwise indicated, nucleic acids are written left to right in 5' to 3' orientation; amino acid sequences are written left to right in amino to carboxy orientation, respectively. It is to be understood that this invention is not limited to the particular methodology, protocols, and reagents described, as these may vary, depending upon the context they are used by those of skill in the art.

Furthermore, the headings provided herein are not limitations of the various aspects or embodiments of the invention which can be had by reference to the specification as a whole. Accordingly, the terms defined immediately below are more fully defined by reference to the specification as a whole. Nonetheless, in order to facilitate understanding of the invention, a number of terms are defined below.

Definitions

As used herein, the term "transforming growth factor" (TGF) refers to any member of this family of proteins, including those in the subgroup designated "TGFβ" known to those of skill in the art. In particularly preferred embodiments, the term is used in reference to TGFβ-1 and TGFβ-2.

As used herein, in some embodiments, the "compound" comprises the "complete" protein, (*i.e.*, in its entire length as it occurs in nature (or as mutated)), while in other embodiments it comprises a truncated form of a protein. Thus, the compounds of the present invention are either truncated or be "full-length." In addition, in some embodiments, the truncation is located at the N-terminal end, while in other embodiments the truncation is located at the C-terminal end of the protein. In further embodiments, the compound lacks one or more portions (*e.g.*, sub-sequences, signal sequences, domains or moieties), whether active or not.

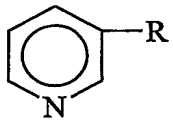
The term "organism" is used throughout the specification to describe an animal, preferably a human, to whom treatment, including prophylactic treatment, with the compounds according to the present invention is provided. For treatment of those infections, conditions or

disease states which are specific for a specific animal such as a human patient, the term organism refers to that specific animal.

The "host cells" used in the present invention generally are prokaryotic or eukaryotic hosts which contain an expression vector and/or gene of interest. Host cells are transformed or transfected with vectors constructed using recombinant DNA techniques. Such transformed host cells are capable of either replicating vectors encoding the protein variants or expressing the desired protein variant. In the case of vectors which encode the pre- or prepro-form of the protein variant, such variants, when expressed, are typically secreted from the host cell into the host cell medium.

The term "effective amount" is used throughout the specification to describe concentrations or amounts of compounds according to the present invention which may be used to produce a favorable change in the disease or condition treated, whether that change is hair growth or prevention of hair growth.

As used herein, "vitamin B_3 compound" means a compound having the formula:



wherein R is - $CONH_2$ (*i.e.*, niacinamide), - COOH (*i.e.*, nicotinic acid) or - CH_2OH (*i.e.*, nicotinyl alcohol); derivatives thereof; and salts of any of the foregoing.

As used herein, "non-vasodilating" means that an ester does not commonly yield a visible flushing response after application to the skin in the subject compositions. It is contemplated that the majority of the general population would not experience a visible flushing response, although such compounds may cause vasodilation not visible to the naked eye.

As used herein, "retinoid" includes all natural and/or synthetic analogs of Vitamin A and/or retinol-like compounds which possess the biological activity of Vitamin A in/on the skin, as well as the geometric isomers and stereoisomers of these compounds.

As used herein, the term "bioactivity" refers to a cause and effect relationship between a composition and a biological system. Thus, the term is used as by those skilled in the art of biotechnology and biological sciences as the phrase that describes a cause and effect relationship between a molecular composition and living biological matter (*e.g.*, tissue, cells, etc.).

As used herein as a noun, the term "bioactive" refers a composition that exhibits bioactivity upon administration to living biological matter (*e.g.*, tissue, cells, etc.). The term is used synonymously with "bioactive compound."

As used herein, "silicone gum" means high molecular weight silicones having an average molecular weight in excess of about 200,000 and preferably from about 200,000 to about

4,000,000. It is intended that the definition encompass non-volatile polyalkyl and polyaryl siloxane gums.

As used herein, the term "polypeptide" refers to a compound made up of a single chain of amino acid residues linked by peptide bonds. The term "protein" herein may be synonymous with the term "polypeptide" or may refer, in addition, to a complex of two or more polypeptides. The exact meaning is that known to those in the art.

As used herein, the terms "expression cassette" and "expression vector" refer to nucleic acid constructs generated recombinantly or synthetically, with a series of specified nucleic acid elements that permit transcription of a particular nucleic acid in a target cell. The recombinant expression cassette can be incorporated into a plasmid, chromosome, mitochondrial DNA, plastid DNA, virus, or nucleic acid fragment. Typically, the recombinant expression cassette portion of an expression vector includes, among other sequences, a nucleic acid sequence to be transcribed and a promoter. The term "expression cassette" may be used interchangeably herein with "DNA construct" and its grammatical equivalents.

As used herein, the terms "vector" and "cloning vector" refer to nucleic acid constructs designed to transfer nucleic acid sequences into cells.

As used herein, the term "expression vector" refers to a vector that has the ability to incorporate and express heterologous DNA fragments in a foreign cell. Many prokaryotic and eukaryotic expression vectors are commercially available. Selection of appropriate expression vectors is within the knowledge of those of skill in the art.

As used herein, the term "plasmid" refers to a circular double-stranded (ds) DNA construct used as a cloning vector, and which forms an extrachromosomal self-replicating genetic element in some eukaryotes or integrates into the host chromosomes.

As used herein, the term "expression" refers to the process by which a polypeptide is produced based on the nucleic acid sequence of the gene or the chemical synthetic peptide. The process includes both transcription and translation of the gene to produce polypeptide/protein.

As used herein, the term "gene" means the segment of DNA involved in producing a polypeptide chain that may or may not include regions preceding or following the coding region.

As used herein, the terms "nucleic acid molecule" and "nucleic acid sequence" include sequences of any form of nucleic acid, including, but not limited to RNA, DNA and cDNA molecules. It will be understood that, as a result of the degeneracy of the genetic code, a multitude of nucleotide sequences encoding a given protein may be produced, in addition to mutant proteins.

As used herein, "codon" refers to a sequence of three nucleotides in a DNA or mRNA molecule that represents the instruction for incorporation of a specific amino acid into a polypeptide chain.

As used herein, the term "disulfide bridge" or "disulfide bond" refers to the bond formed between the sulfur atoms of cysteine residues in a polypeptide or a protein. In this invention, a disulfide bridge or disulfide bond may be non-naturally occurring and introduced by way of point mutation.

As used herein, the term "salt bridge" refers to the bond formed between oppositely charged residues, amino acids in a polypeptide or protein. In this invention, a salt bridge may be non-naturally occurring and introduced by way of point mutation.

As used herein, an "enzyme" refers to a protein or polypeptide that catalyzes at least one chemical reaction.

As used herein, the term "activity" refers to any activity associated with a particular protein, such as enzymatic activity associated with a protease. In some embodiments, the activity is biological activity. In further embodiments, activity encompasses binding of proteins to receptors which results in measurable downstream effects, such as inhibition of the transition from anagen to catagen, as described herein. "Biological activity" refers to any activity that would normally be attributed to that protein by one skilled in the art.

As used herein, the term "protease" refers to an enzyme that degrades peptide bonds.

As used herein, "peptide bond" refers to the chemical bond between the carbonyl group of one amino acid and the amino group of another amino acid.

As used herein, "wild-type" refers to a sequence or a protein that is native or naturally occurring.

As used herein, "point mutations" refers to a change in a single nucleotide of DNA, especially where that change results in a sequence change in a protein.

As used herein, "mutant" refers to a version of an organism or protein where the version is other than wild-type. The change may be effected by methods well known to one skilled in the art, for example, by point mutation in which the resulting protein may be referred to as a mutant.

As used herein, "mutagenesis" refers to the process of changing a composition (*e.g.*, protein) from a wild-type composition (*e.g.*, protein) into a mutant or variant composition (*e.g.*, protein).

As used herein, "substituted" and "substitutions" refer to replacement(s) of an amino acid residue or nucleic acid base in a parent sequence. In some embodiments, the substitution involves the replacement of a naturally occurring residue or base.

As used herein, "modification" and "modify" refer to any change(s) in an amino acid or nucleic acid sequence, including, but not limited to deletions, insertions, interruptions, and substitutions. In some embodiments, the modification involves the replacement of a naturally occurring residue or base.

As used herein, "functional portion of a secreted polypeptide" and its grammatical equivalents refers to a truncated secreted polypeptide that retains its ability to fold into a normal, albeit truncated, configuration. In some embodiments, it is contemplated that sufficient residues of a domain of the naturally secreted polypeptide must be present to allow it to fold in its normal configuration independently of the desired polypeptide to which it is attached. However, in most cases, the portion of the secreted polypeptide are both correctly folded and result in increased secretion as compared to its absence. Similarly, in most cases, the truncation of the secreted polypeptide means that the functional portion retains a biological function. In a preferred embodiment, the catalytic domain of a secreted polypeptide is used, although other functional domains may be used, for example, the substrate binding domains. Additionally preferred embodiments utilize the catalytic domain and all or part of the linker region.

As used herein, "loop" refers to a sequence of amino acids, for example 3-20 amino acids, more preferably 5-15 amino acids, even more preferably 5-10 amino acids, and most preferably 7-9 amino acids, which connects structural elements of a protein. Such elements include, but are not limited to beta sheets and helical elements and the connecting loop of a beta-hairpin. In some embodiments, the loop is further stabilized through the use of covalent linkages. In some preferred embodiments, the covalent linkages comprise disulfide bonds, especially as provided herein. In alternative embodiments, the loops are stabilized by the use of other means, including but not limited to amides, hydrogen bonds, and/or salt bridges. In most embodiments, the loops are located on the surface of proteins and may be altered, as provided herein, to confer additional (*e.g.,* desirable) properties to the requisite proteins.

As used herein, "oligonucleotide" refers to a short nucleotide sequence which may be used, for example, as a primer in a reaction used to create mutant proteins.

As used herein, the terms "an oligonucleotide having a nucleotide sequence encoding a gene" and "polynucleotide having a nucleotide sequence encoding a gene," means a nucleic acid sequence comprising the coding region of a gene or in other words the nucleic acid sequence which encodes a gene product. The coding region may be present in either a cDNA, genomic DNA or RNA form. When present in a DNA form, the oligonucleotide or polynucleotide may be single-stranded (*i.e.*, the sense strand) or double-stranded. Suitable control elements such as enhancers/promoters, splice junctions, polyadenylation signals, *etc.* may be placed in close proximity to the coding region of the gene if needed to permit proper initiation of transcription and/or correct processing of the primary RNA transcript. Alternatively, the coding region utilized in the expression vectors of the present invention may contain endogenous enhancers/promoters, splice junctions, intervening sequences, polyadenylation signals, *etc.* or a combination of both endogenous and exogenous control elements.

As used herein, the term "primer" refers to an oligonucleotide, whether occurring naturally as in a purified restriction digest or produced synthetically, which is capable of acting as a point of initiation of synthesis when placed under conditions in which synthesis of a primer extension product which is complementary to a nucleic acid strand is induced, (*i.e.*, in the presence of nucleotides and an inducing agent such as DNA polymerase and at a suitable temperature and pH). The primer is preferably single stranded for maximum efficiency in amplification, but may alternatively be double stranded. If double stranded, the primer is first treated to separate its strands before being used to prepare extension products. Preferably, the primer is an oligodeoxyribonucleotide. The primer must be sufficiently long to prime the synthesis of extension products in the presence of the inducing agent. The exact lengths of the primers will depend on many factors, including temperature, source of primer and the use of the method.

As used herein, the term "probe" refers to an oligonucleotide (*i.e.*, a sequence of nucleotides), whether occurring naturally as in a purified restriction digest or produced synthetically, recombinantly or by PCR amplification, which is capable of hybridizing to another oligonucleotide of interest. A probe may be single-stranded or double-stranded. Probes are useful in the detection, identification and isolation of particular gene sequences. It is contemplated that any probe used in the present invention will be labelled with any "reporter molecule," so that is detectable in any detection system, including, but not limited to enzyme (*e.g.*, ELISA, as well as enzyme-based histochemical assays), fluorescent, radioactive, and luminescent systems. It is not intended that the present invention be limited to any particular detection system or label.

As used herein, the term "target," when used in reference to the polymerase chain reaction, refers to the region of nucleic acid bounded by the primers used for polymerase chain reaction. Thus, the "target" is sought to be sorted out from other nucleic acid sequences. A "segment" is defined as a region of nucleic acid within the target sequence.

As used herein, the term "polymerase chain reaction" ("PCR") refers to the method well-known in the art (*See e.g.*, U.S. Patent Nos. 4,683,195 4,683,202, and 4,965,188, hereby incorporated by reference), for increasing the concentration of a segment of a target sequence in a mixture of genomic DNA without cloning or purification. This process for amplifying the target sequence consists of introducing a large excess of two oligonucleotide primers to the DNA mixture containing the desired target sequence, followed by a precise sequence of thermal cycling in the presence of a DNA polymerase. The two primers are complementary to their respective strands of the double stranded target sequence. To effect amplification, the mixture is denatured and the primers then annealed to their complementary sequences within the target molecule. Following annealing, the primers are extended with a polymerase so as to form a new pair of

complementary strands. The steps of denaturation, primer annealing and polymerase extension can be repeated many times (*i.e.*, denaturation, annealing and extension constitute one "cycle"; there can be numerous "cycles") to obtain a high concentration of an amplified segment of the desired target sequence. The length of the amplified segment of the desired target sequence is determined by the relative positions of the primers with respect to each other, and therefore, this length is a controllable parameter. By virtue of the repeating aspect of the process, the method is referred to as the "polymerase chain reaction" (hereinafter "PCR"). Because the desired amplified segments of the target sequence become the predominant sequences (in terms of concentration) in the mixture, they are said to be "PCR amplified".

As used herein, the terms "PCR product," "PCR fragment," and "amplification product" refer to the resultant mixture of compounds after two or more cycles of the PCR steps of denaturation, annealing and extension are complete. These terms encompass the case where there has been amplification of one or more segments of one or more target sequences.

As used herein, the term "amplification reagents" refers to those reagents (deoxyribonucleotide triphosphates, buffer, etc.), needed for amplification except for primers, nucleic acid template and the amplification enzyme. Typically, amplification reagents along with other reaction components are placed and contained in a reaction vessel (test tube, microwell, etc.).

As used herein, the term "RT-PCR" refers to the replication and amplification of RNA sequences. In this method, reverse transcription is coupled to PCR, most often using a one enzyme procedure in which a thermostable polymerase is employed, as described in U.S. Patent No. 5,322,770, herein incorporated by reference. In RT-PCR, the RNA template is converted to cDNA due to the reverse transcriptase activity of the polymerase, and then amplified using the polymerizing activity of the polymerase (*i.e.*, as in other PCR methods).

As used herein, the term "hybridization" refers to the process by which a strand of nucleic acid joins with a complementary strand through base pairing, as known in the art.

As used herein, "maximum stringency" refers to the level of hybridization that typically occurs at about Tm-5°C (5°C below the Tm of the probe); "high stringency" at about 5°C to 10°C below Tm; "intermediate stringency" at about 10°C to 20°C below Tm; and "low stringency" at about 20°C to 25°C below Tm. As will be understood by those of skill in the art, a maximum stringency hybridization can be used to identify or detect identical polynucleotide sequences while an intermediate or low stringency hybridization can be used to identify or detect polynucleotide sequence homologs.

The phrases "substantially similar and "substantially identical" in the context of two nucleic acids or polypeptides typically means that a polynucleotide or polypeptide comprises a sequence that has at least 75% sequence identity, preferably at least 80%, more preferably at least

90%, still more preferably 95%, most preferably 97%, sometimes as much as 98% and 99% sequence identity, compared to the reference (*i.e.*, wild-type) sequence. Sequence identity may be determined using known programs such as BLAST, ALIGN, and CLUSTAL using standard parameters. (*See e.g.*, Altschul, *et al.*, J. Mol. Biol. 215:403-410 [1990]; Henikoff *et al.*, Proc. Natl. Acad Sci. USA 89:10915 [1989]; Karin *et al.*, Proc. Natl Acad. Sci USA 90:5873 [1993]; and Higgins *et al.*, Gene 73:237 - 244 [1988]). Software for performing BLAST analyses is publicly available through the National Center for Biotechnology Information. Also, databases may be searched using FASTA (Pearson *et al.*, Proc. Natl. Acad. Sci. USA 85:2444-2448 [1988]).

As used herein, "equivalent residues" refers to proteins that share particular amino acid residues. For example, equivalent resides may be identified by determining homology at the level of tertiary structure for a protein (*e.g.* TGFβ) whose tertiary structure has been determined by x-ray crystallography. Equivalent residues are defined as those for which the atomic coordinates of two or more of the main chain atoms of a particular amino acid residue of the protein having putative equivalent residues and the protein of interest (N on N, CA on CA, C on C and O on O) are within 0.13 nm and preferably 0.1 nm after alignment. Alignment is achieved after the best model has been oriented and positioned to give the maximum overlap of atomic coordinates of non-hydrogen protein atoms of the proteins analyzed. The preferred model is the crystallographic model giving the lowest R factor for experimental diffraction data at the highest resolution available, determined using methods known to those skilled in the art of crystallography and protein characterization/analysis.

In some embodiments, modification is preferably made to the "precursor DNA sequence" which encodes the amino acid sequence of the precursor enzyme, but can be by the manipulation of the precursor protein. In the case of residues which are not conserved, the replacement of one or more amino acids is limited to substitutions which produce a variant which has an amino acid sequence that does not correspond to one found in nature. In the case of conserved residues, such replacements should not result in a naturally-occurring sequence. Derivatives provided by the present invention further include chemical modification(s) that change the characteristics of the protein.

In some preferred embodiments, the protein gene is ligated into an appropriate expression plasmid. The cloned protein gene is then used to transform or transfect a host cell in order to express the protein gene. In some embodiments, this plasmid replicates in the hosts, in the sense that it contains the well-known elements necessary for plasmid replication or the plasmid may be designed to integrate into the host chromosome. The necessary elements are provided for efficient gene expression (*e.g.*, a promoter operably linked to the gene of interest). In some embodiments, these necessary elements are supplied as the gene's own homologous promoter if it

is recognized, (*i.e.*, transcribed, by the host), a transcription terminator (a polyadenylation region for eukaryotic host cells) which is exogenous or is supplied by the endogenous terminator region of the protein gene. In some embodiments, a selection gene such as an antibiotic resistance gene that enables continuous cultural maintenance of plasmid-infected host cells by growth in antimicrobial-containing media is also included.

As used herein, the terms "restriction endonucleases" and "restriction enzymes" refer to bacterial enzymes, each of which cut double-stranded DNA at or near a specific nucleotide sequence.

As used herein, the term "recombinant DNA molecule" as used herein refers to a DNA molecule which is comprised of segments of DNA joined together by means of molecular biological techniques.

The term "recombinant protein" or "recombinant polypeptide" as used herein refers to a protein molecule which is expressed from a recombinant DNA molecule.

The term "native protein" as used herein to indicate that a protein does not contain amino acid residues encoded by vector sequences; that is the native protein contains only those amino acids found in the protein as it occurs in nature. A native protein may be produced by recombinant means or may be isolated from a naturally occurring source.

As used herein the term "portion" when in reference to a protein (as in "a portion of a given protein") refers to fragments of that protein. The fragments may range in size from four amino acid residues to the entire amino acid sequence minus one amino acid.

As used herein, the term "fusion protein" refers to a chimeric protein containing the protein of interest (*i.e.*, TGFβ-1 or TGFβ-2 and fragments thereof) joined to an exogenous protein fragment (the fusion partner which consists of a non-TGFβ protein). In some embodiments, the fusion partner enhances solubility of the TGFβ protein as expressed in a host cell, may provide an affinity tag to allow purification of the recombinant fusion protein from the host cell or culture supernatant, or both. If desired, the fusion protein may be removed from the protein of interest (*i.e.*, TGFβ-1 and/or TGFβ-2 or fragments thereof) by a variety of enzymatic or chemical means known to the art.

The terms "in operable combination," "in operable order," and "operably linked" as used herein refer to the linkage of nucleic acid sequences in such a manner that a nucleic acid molecule capable of directing the transcription of a given gene and/or the synthesis of a desired protein molecule is produced. The term also refers to the linkage of amino acid sequences in such a manner so that a functional protein is produced.

As used herein the term "coding region" when used in reference to structural gene refers to the nucleotide sequences which encode the amino acids found in the nascent polypeptide as a result of translation of a mRNA molecule. The coding region is bounded, in eukaryotes, on the 5'

side by the nucleotide triplet "ATG" which encodes the initiator methionine and on the 3' side by one of the three triplets which specify stop codons (*i.e.*, TAA, TAG, TGA).

As used herein, the term "structural gene" refers to a DNA sequence coding for RNA or a protein. In contrast, "regulatory genes" are structural genes which encode products which control the expression of other genes (*e.g.*, transcription factors).

As used herein, the term "purified" or "to purify" refers to the removal of contaminants from a sample. For example, recombinant TGFβ polypeptides are expressed in host cells and the polypeptides are purified by the removal of host cell proteins; the percent of recombinant TGFβ polypeptides is thereby increased in the sample.

The term "isolated" when used in relation to a nucleic acid, as in "an isolated oligonucleotide" or "isolated polynucleotide" refers to a nucleic acid sequence that is identified and separated from at least one contaminant nucleic acid with which it is ordinarily associated in its natural source. Isolated nucleic acid is such present in a form or setting that is different from that in which it is found in nature. In contrast, non-isolated nucleic acids as nucleic acids such as DNA and RNA found in the state they exist in nature. For example, a given DNA sequence (*e.g.*, a gene) is found on the host cell chromosome in proximity to neighboring genes; RNA sequences, such as a specific mRNA sequence encoding a specific protein, are found in the cell as a mixture with numerous other mRNA s which encode a multitude of proteins. However, isolated nucleic acid encoding a TGFβ protein includes, by way of example, such nucleic acid in cells ordinarily expressing a TGFβ protein where the nucleic acid is in a chromosomal location different from that of natural cells, or is otherwise flanked by a different nucleic acid sequence than that found in nature. The isolated nucleic acid, oligonucleotide, or polynucleotide may be present in single-stranded or double-stranded form. When an isolated nucleic acid, oligonucleotide or polynucleotide is to be utilized to express a protein, the oligonucleotide or polynucleotide will contain at a minimum the sense or coding strand (*i.e.*, the oligonucleotide or polynucleotide may single-stranded), but may contain both the sense and anti-sense strands (*i.e.*, the oligonucleotide or polynucleotide may be double-stranded).

As used herein, "anagen" refers to the active growth phase of hair follicles. In the anagen phase, cells in the root of the hair divide rapidly, adding to the hair shaft. During this phase, the hair grows about 1 cm every 28 days. Scalp hair stays in this active phase of growth for 2-6 years.

As used herein, "catagen" refers to the hair growth phase that occurs at the end of the anagen phase. It signals the end of the active growth of a hair. This phase lasts for about 2-3 weeks while a club hair is formed.

As used herein, "telogen" refers to the resting phase of the hair follicle. At any given time, 10%-15% of all hairs are in the telogen phase. This phase lasts for about 100 days for hairs on the scalp and much longer for hairs on the eyebrows, eyelashes, arms and legs. During this

phase, the hair follicle is completely at rest and the club hair is completely formed. Pulling out a hair in this phase will reveal a solid, hard, dry, white material at the root. About 25-100 telogen hairs are shed normally each day.

As used herein, "depilation" refers to the act of removing hair. "Depilatories" are compositions that are used to remove hair.

As used herein, "alopecia" refers to loss of hair. Hair loss is thought to proceed by mechanisms involving TGFβ-1 and/or TGFβ-2, as described herein. However, it is not intended that the present invention be limited to any particular mechanism in hair loss.

As used herein, "cosmetic composition" refers to compositions that find use in the cosmetics. The Food Drug and Cosmetic Act (FD&C Act) definition is used herein. Thus, cosmetics are defined by their intended use, as articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body for cleansing, beautifying, promoting attractiveness, or altering appearance. These compositions provide non-therapeutic benefits and are not regulated as pharmaceuticals. However, in some situations, cosmetic compositions are incorporated into pharmaceutical compositions to provide cosmetic benefits (*e.g.*, products that treat skin or hair diseases, but also contain cosmetic compositions for their coloring or other benefits). Also, it is intended that the present invention encompass the use of cosmetics on animals other than humans.

As used herein, the terms "pharmaceutical compositions" and "therapeutic compositions" refer to compositions such as drugs that provide medical benefits, rather than solely cosmetic benefits. In the United States, pharmaceutical and therapeutic compositions are approved by the Food and Drug Administration for treatment and/or prevention of particular conditions.

As used herein, the term "drug" is defined as it is in the FD&C Act definition. Thus, drugs are defined as articles intended for use in the diagnosis, cure, mitigation, treatment or prevention of disease, and articles (other than food) intended to affect the structure or any function of the body of man or other animals.

As used herein, the term "cosmetic benefit" refers to a desired cosmetic change that results from the administration of a personal care composition. Cosmetic benefits include but are not limited to improvements in the condition of skin, hair, nails, and the oral cavity. In preferred embodiments, at least one cosmetic benefit is provided by the skin care, hair care, nail care, and makeup compositions of the present invention.

As used herein, "skin care composition" refers to compositions that are applied to skin in order to provide beneficial properties, including but not limited to wrinkle minimizing, wrinkle removal, decoloring, coloring, skin softening, skin smoothing, dipilation, cleansing, etc. In some particularly preferred embodiments, the present invention provides skin care compositions that

improve skin tone. In these embodiments, the improvement comprises lessening of wrinkles, smoothing skin texture, modifying skin coloration, and other desired cosmetic benefits.

As used herein, "hair care composition" refers to compositions that are applied to hair to provide beneficial properties such as thickening, thinning, coloring, decoloring, cleansing, conditioning, softening, shaping, etc.

As used herein, "makeup compositions" refer to cosmetic preparations that are used to beautify, caring for, maintaining, or augment the appearance of a human or other animal. "Makeup compositions" include, but are not limited to color cosmetics, such as mascaras, lipsticks, lip liners, eye shadows, eye-liners, rouges, face powders, foundations, blushes, and nail polish.

As used herein, the term "dispersed phase" is used as by those of skill in the art of emulsion technology as the phase that exists as small particles or droplets suspended in and surrounded by a continuous phase. The dispersed phase is also known as the "internal" or "discontinuous" phase.

As used herein, "penetration enhancers" refer to compositions that facilitate penetration through the upper stratum corneum barrier to the deeper skin layers. Examples of penetration enhancers include, but are not limited to, propylene glycol, azone, ethoxydiglycol, dimethyl isosorbide, urea, ethanol, dimethyl sulfoxide, micoroemulsions, liposomes, and nanoemulsions.

As used herein, the terms "emulsifier" and "surfactant" refer to compounds that disperse and suspend the dispersed phase within the continuous phase of a material. Surfactants find particular use in products intended for skin and/or hair cleansing. In particular embodiments, the term "surfactant(s)" is used in reference to surface-active agents, whether used as emulsifiers or for other surfactant purposes such as skin cleansing.

Detailed Description of the Invention

The present invention provides peptides and supported peptides that bind TGFβ molecules. In some particularly preferred embodiments, the TGFβ binding molecules bind TGFβ-1, while in other embodiments, the TGFβ binding molecules bind TGFβ-2.

The present invention provides peptides and supported peptides which bind TGFβ-1 and/or TGFβ-2. In some preferred embodiments, the present invention provides cosmetic and/or pharmaceutical compounds for modulating hair growth. The present invention provides peptides that bind and block binding of TGFβ-1 and/or TGFβ-2, wherein the peptide is expressed in a protease-resistant scaffold. In some embodiments, the scaffold is a protease inhibitor (*e.g.*, BBI, STI, or Eglin chymotrypsin inhibitor).

In some embodiments, the present invention provides cosmetic and/or pharmaceutical compounds for modulating hair growth comprising at least one polypeptide or a peptide. In some preferred embodiments, the compound comprises at least one polypeptide.

In other preferred embodiments, the compounds comprises at least one peptide. In some preferred embodiments, the peptide has an amino acid sequence selected from the group consisting of SEQ ID NOS:2, 4, and 6 (*See*, Table 1) or SEQ ID NOS:8, 10, 12, 14, and 16 (*See*, Table 2). In some preferred embodiments, the compound have a nucleic acid sequence, the sequence being at least 70%, preferably 80%, more preferably 90%, and most preferably 95% homologous to the sequences set forth herein. In some preferred embodiments, the compounds have an amino acid sequence, the sequence being at least 70%, preferably 80%, more preferably 90%, and most preferably 95% homologous to the sequences set forth herein. In some preferred embodiments, the polypeptide has a molecular weight that is between 500 Daltons and 30,000 Daltons, preferably between 1000 Daltons and 10,000 Daltons, and more preferably between 1500 Daltons to 8,000 Daltons.

In some preferred embodiments, modulation comprises treatment of at least one disease or condition that involves loss of hair. In some of these preferred embodiments, the disease or condition is at least one selected from the group consisting of inflammatory alopecias, pseudopelade, scleroderma, tick bites, lichen planus, psoriasis, lupus, seborrheic dermatitis, loose hair syndrome, hemochromatosis, androgenic alopecia, alopecia areata, cancer, conditions that affect defective hair fiber production, and environmental factors that affect hair production. In a preferred embodiment, the disease is androgenic alopecia or alopecia areata.

In some particularly preferred embodiments, the modulation comprises inhibition of hair growth (*i.e.*, removal and/or inhibition) for at least one disease or condition for which hair growth is not desirable. In some preferred embodiments, hair growth inhibition comprises depilation.

The present invention also provides cosmetic and/or pharmaceutical compounds for modulating hair growth, comprising at least one peptide or at least one polypeptide and a scaffold. In some preferred embodiments, the peptide or polypeptide sequence is contained in the scaffold. In some particularly preferred embodiments, the peptide or polypeptide comprises a loop, while in some more preferred embodiments, the loop is closed by a disulfide bond. In some embodiments, the at least one peptide or polypeptide binds to TGFβ-1 and/or TGFβ-2 and blocks downstream activity of the factor(s). In some preferred embodiments, the scaffold is STI, while in others it is Eglin, and in still others it is BBI. In some preferred embodiments, the most preferred scaffold is BBI. In some preferred embodiments, the compound is at least one polypeptide.

In some additional preferred embodiment, the compound comprises at least one peptide. In some preferred embodiments, the peptide has an amino acid sequence selected from the group

consisting of SEQ ID NOS:2, 4, 6, 8, 10, 12, 14, and 16 (*See*, Tables 1 and 2). In some preferred embodiments, the compound has at least one sequence, the sequence being at least 70%, preferably 80%, more preferably 90%, and most preferably 95% homologous to the sequences set forth herein. In some preferred embodiments, the polypeptide has a molecular weight that is between 500 Daltons and 100,000 Daltons, preferably between 500 Daltons and 45,000 Daltons, more preferably between 1000 Daltons and 12,000 Daltons, preferably between 1500 Daltons to 10,000 Daltons.

In some preferred embodiments, modulation comprises treatment of at least one disease or condition that involves loss of hair. In some particularly preferred embodiment, the disease or condition is at least one selected from the group consisting of inflammatory alopecias, pseudopelade, scleroderma, tick bites, lichen planus, psoriasis, lupus, seborrheic dermatitis, loose hair syndrome, hemochromatosis, androgenic alopecia, alopecia areata, cancer, conditions that affect defective hair fiber production, and environmental factors that affect hair production. In some preferred embodiments, the disease is androgenic alopecia or alopecia areata.

In some preferred embodiments, modulation comprises inhibition of hair growth and/or hair removal for at least one disease or condition for which hair growth is undesirable. In some embodiments, inhibition comprises depilation.

In additional preferred embodiments, the present invention is directed to at least one peptide or polypeptide, at least one loop and at least one protease-resistant scaffold. Flexible native loops are found on the surface of most protein modules and exist as short stretches of amino acids that connect regions of defined secondary structure. Although crystallographic and NMR (nuclear magnetic resonance) studies show that native loops are usually less well defined than alpha-helices and beta-sheets, their conformational freedom is normally restricted substantially compared with free peptides. Consequently, the binding activities of native loops in proteins usually differ significantly from those of the corresponding linear amino acid sequence. However, it is not intended that the present invention be limited to any specific mechanism.

The loops provided by the present invention bind proteins such as TGFβ-1 and TGFβ-2. Binding the loop to the protein prevents the protein from binding to its target. Thus, binding interactions are thought to be disrupted by binding the loop to the protein. As a result, bioactivity can be altered as desired. However, it is not intended that the present invention be limited to any particular mechanism.

The present invention further provides scaffolds to stabilize the loops. STI, BBI and EglinC have native loops that bind to and inhibit proteases. In some embodiments, STI and BBI native loops are replaced with the polypeptides and/or peptides of the invention. In some embodiments, these sequences are replaced with inhibitors or enhancers of TGFβ-1, while in other embodiments, the sequences are replaced with inhibitors or enhancers of TGFβ-2. In

additional embodiments, STI and BBI native loops are replaced with sequences that have been isolated using various techniques known in the art (*e.g.*, phage display),. such as TGFβ-1 binding proteins described herein.

In some embodiments, a native loop is replaced with a loop which is 3 to 20 amino acids in length, preferably 5 to 15 amino acids in length, and more preferably 5 to 10 amino acids in length. In alternative embodiments, longer sequences find use, as long as they provide binding and/or inhibition. In addition, peptides suitable for use as replacements of the native loop(s) can form constrained loops (*i.e.*, a loop formed by the presence to a disulfide bond between two cysteine residues). In some particularly preferred embodiments, the peptides are between 7 and 9 amino acids in length.

There are several advantages to using scaffolds to stabilize peptide sequences. In some preferred embodiments, the biological activity of the peptide is higher and/or effectively modulates biological function as a result of limiting peptide flexibility and reducing the entropic cost of fixing the polypeptide sequence in the bioactive conformation. In addition, structural information obtained by x-ray crystallography finds use in guiding affinity maturation. Furthermore, in some embodiments, the sequence presented on a structural scaffold is more resistant to proteolytic degradation in different biological applications. In still further embodiments, the chimeric construction is obtained in large amount in low cost biological expression systems for industrial applications.

As shown in the Examples, in some embodiments, the present invention provides compounds that bind TGFβ-1, while in alternative embodiments, the present invention provides compounds that bind TGFβ-2. In some embodiments, binding absorbs extracellular TGFβ-1, thereby preventing TGFβ-1 from interacting with its cognate ligand, when then prevents downstream biological effect(s). In the present invention, binding prevents TGFβ-1 from interacting with its cognate receptor and inhibits transition from the anagen to the catagen promoting hair growth and preventing hair loss. In some embodiments, binding absorbs extracellular TGFβ-2, thereby preventing TGFβ-2 from interacting with its cognate ligand, which then prevents downstream biological effect(s). In the present invention, binding prevents TGFβ-2 from interacting with its cognate receptor and inhibits transition from the anagen to the catagen promoting hair growth and preventing hair loss.

BBI represents a class of protein scaffolds whose binding to proteases is mediated by an exposed native loop that is fixed in a characteristic canonical conformation and which fits into the active site in a manner thought to be similar to that of a substrate (Laskowski and Kato, Ann. Rev. Biochem., 49:593-626 [1980]; and Bode & Huber, *supra*). The native loop is frequently constrained by the presence of disulfide bridges and/or extensive hydrogen-bonding networks that

act to lock the structure into the correct canonical structure. The sequence of this loop determines the specificity of the inhibition, which mirrors the specificity of proteases for their substrates. For example, most trypsin inhibitors have Arg or Lys as their P1 residue. Inhibitors of the BBI family have a network of conserved disulfide bridges that help form a symmetrical structure of two tricyclic domains (Chen *et al.*, *supra*; Werner and Wemmer, *supra*; and Liu *et al.*, *supra*), each containing an independent serine protease binding site. The native binding loop is contained within a region joined by disulfide bridges formed between cysteine residues. The identity of the amino acid residue at the P1 site on each domain is the main determinant of the serine protease inhibited. Native domains possess lysine or arginine for trypsin, leucine or tyrosine for chymotrypsin and alanine for elastase (Tsunogae *et al.*, J. Biochem. (Tokyo) 100:243-246 [1986]). In addition, serine is highly conserved at the P'1 position and proline at the P'3 position. The individual native loop regions of BBI are well suited for protein loop grafting of previously identified cysteine constrained peptides that bind to targets selectively, as described herein.

Numerous isoforms of BBI have been characterized. For example, SEQ ID NO:17 (*See*, Figure 2) provides the amino acid sequence of a BBI backbone described herein comprising approximately 71 amino acid residues. In addition, in some embodiments BBI is truncated with as many as 10 amino acid residues being removed from either the N- or C- terminal. Any of the isoforms described herein, as well as those additional ones known in the art, find use as scaffolds in the present invention.

The present invention provides several advantages over creation of, for example, chimeric proteins. Transfer of an entire protein can be difficult when, for example, a protein domain of interest carries more than one important biological activity. Maintaining one activity (*e.g.* functionally significant domain-domain interactions) while altering another (*e.g.* high affinity binding to a co-factor or receptor) can be problematic. The present invention, as indicated herein, overcomes that limitation, as in preferred embodiments the loops are transferred, instead of entire domains.

In addition, in some embodiments, the compounds of the present invention comprise at least one mutation in addition to those set out above. Other mutations, such as deletions, insertions, substitutions, transversions, transitions and inversions, at one or more other locations, also find use in the present invention.

In some embodiments, the compounds of the present invention also comprise a conservative substitution that may occur as a like-for-like substitution (*e.g.*, basic for basic, acidic for acidic, polar for polar etc.). In additional embodiments, non-conservative substitutions are provided (*i.e.*, from one class of residue to another or alternatively involving the inclusion of

unnatural amino acids such as ornithine, diaminobutyric acid ornithine, norleucine ornithine, pyriylalanine, thienylalanine, naphthylalanine and phenylglycine).

In some embodiments, the sequences also have deletions, insertions and/or substitutions of amino acid residues that produce a silent change and result in a functionally equivalent substance.

In some embodiments, deliberate amino acid substitutions are made on the basis of similarity in amino acid properties (*e.g.*, polarity, charge, solubility, hydrophobicity, hydrophilicity, and/or the amphipathic nature of the residues) and it is therefore useful to group amino acids together in functional groups. Amino acids can be grouped together based on the properties of their side chain alone. However it is more useful to include mutation data as well. The sets of amino acids thus derived are likely to be conserved for structural reasons. These sets can be described in the form of a Venn diagram (*See e.g.*, Livingstone and Barton, Comput. Appl Biosci., 9:745-756 [1993]; and (Taylor, J. Theor. Biol., 119:205-218 [1986]). In some embodiments, conservative substitutions are made, for example according to the table below that describes a generally accepted Venn diagram grouping of amino acids.

Set		Sub-set	
Hydrophobic	F W Y H K M I L V A G C	Aromatic	F W Y H
		Aliphatic	I L V
Polar	W Y H K R E D C S T N Q	Charged	H K R E D
		Positively charged	H K R
		Negatively charged	E D
Small	V C A G S P T N D	Tiny	A G S

In some embodiments, variant amino acid sequences of the present invention also include suitable spacer groups inserted between any two amino acid residues of the sequence including alkyl groups such as methyl, ethyl or propyl groups in addition to amino acid spacers such as glycine or β-alanine residues. A further form of variation involves the presence of one or more amino acid residues in peptoid form.

In some embodiments, homology comparisons find use in identifying homologous sequences that find use in the present invention. Homology comparisons can be conducted by eye, or more usually, with the aid of readily available sequence comparison programs. Available computer programs can calculate the percent homology between two or more sequences. Additionally, percent homology may be calculated over contiguous sequences (*i.e.*, one sequence is aligned with the other sequence and each amino acid in one sequence is directly compared with the corresponding amino acid in the other sequence one residue at a time). This is called an

"ungapped" alignment. Typically, such ungapped alignments are performed only over a relatively short number of residues.

Although this is a very simple and consistent method, it fails to take into consideration that, for example, in an otherwise identical pair of sequences, one insertion or deletion will cause following amino acid residues to be put out of alignment, thus potentially resulting in a large reduction in % homology when a global alignment is performed. Consequently, most sequence comparison methods are designed to produce optimal alignments that take into consideration possible insertions and deletions without penalizing unduly the overall homology score. This is achieved by inserting "gaps" in the sequence alignment to try to maximize local homology.

However, these more complex methods assign "gap penalties" to each gap that occurs in the alignment, so that for the same number of identical amino acids, a sequence alignment with as few gaps as possible (*i.e.,* reflecting higher relatedness between the two compared sequences) will achieve a higher score than one with many gaps. "Affine gap costs" are typically used that charge a relatively high cost for the existence of a gap and a smaller penalty for each subsequent residue in the gap. This is one of the most commonly used gap scoring system. High gap penalties will of course produce optimized alignments with fewer gaps. Most alignment programs allow the gap penalties to be modified. However, it is preferred to use the default values when using such software for sequence comparisons. For example when using the GCG Wisconsin Bestfit package the default gap penalty for amino acid sequences is -12 for a gap and -4 for each extension.

Calculation of maximum % homology therefore firstly requires the production of an optimal alignment, taking into consideration gap penalties. A suitable computer program for carrying out such an alignment is the GCG Wisconsin Bestfit package (*See e.g.,* Devereux *et al.,* Nuc. Acids Res., 12:387 [1984]). Examples of other software packages than can perform sequence comparisons include, but are not limited to, the BLAST package FASTA, and the GENEWORKS suite of comparison tools, all of which are well-known to those in the art. Both BLAST and FASTA are available for offline and online searching. However, for some applications, it is preferred to use the GCG Bestfit program. The BLAST 2 Sequence package is also available for comparing protein and nucleotide sequences.

Although the final percent homology can be measured in terms of identity, the alignment process itself is typically not based on an all-or-nothing pair comparison. Instead, a scaled similarity score matrix is generally used that assigns scores to each pair-wise comparison based on chemical similarity or evolutionary distance. An example of such a matrix commonly used is the BLOSUM62 matrix - the default matrix for the BLAST suite of programs. GCG Wisconsin programs generally use either the public default values or a custom symbol comparison table if

supplied. For some applications, it is preferred to use the public default values for the GCG package, or in the case of other software, the default matrix, such as BLOSUM62.

Alternatively, percentage homologies may be calculated using the multiple alignment feature in DNASIS™ (Hitachi Software), based on an algorithm, analogous to CLUSTAL (*See e.g.,* Higgins and Sharp, Gene 73:237-244 [1988]).

Once the software has produced an optimal alignment, it is possible to calculate the percent of homology, and more preferably, the percent of sequence identity. The software typically does this as part of the sequence comparison and generates a numerical result.

In some embodiments, the present invention provides nucleic acids encoding any of the compounds described herein, as well as complements thereof. In additional preferred embodiments, the invention provides vectors comprising a compound, as disclosed herein, cells comprising the compound and methods of expressing the compound.

Those of skill in the art appreciate the relationship between nucleic acid sequences and polypeptide sequences, in particular as relate to the genetic code and the degeneracy of this code, and will be able to construct such nucleic acids without difficulty. For example, one skilled in the art is aware that for each amino acid substitution in a sequence there may be one or more codons that encode the substitute amino acid. Accordingly, it is evident that, depending on the degeneracy of the genetic code with respect to that particular amino acid residue, one or more nucleic acid sequences may be generated corresponding to that polypeptide sequence.

Mutations in amino acid sequence and nucleic acid sequence may be made by any of a number of techniques, as known in the art. In particularly preferred embodiments, the mutations are introduced into parent sequences by means of PCR (polymerase chain reaction) using appropriate primers. In some embodiments, the parent enzymes are modified at the amino acid level, while in other embodiments, the enzymes are modified at the nucleic acid level, in order to generate the sequences described herein. In some preferred embodiments, the present invention provides for the generation of compounds by introducing one or more corresponding codon changes in the nucleotide sequence encoding a compound. It will be appreciated that the above codon changes will find use in various nucleic acid sequences of the present invention. For example, in some embodiments, sequence changes are made to any of the homologous sequences described herein.

As indicated above, in some embodiments, the "compound" comprises the "complete" protein, (*i.e.*, in its entire length as it occurs in nature (or as mutated)), while in other embodiments it comprises a truncated form of a protein. Thus, the compounds of the present invention are either truncated or be "full-length." In addition, in some embodiments, the truncation is located at the N-terminal end, while in other embodiments the truncation is located

at the C-terminal end of the protein. In further embodiments, the compound lacks one or more portions (*e.g.*, sub-sequences, signal sequences, domains or moieties), whether active or not.

In yet further alternative embodiments, the nucleotide sequences encoding the compounds are prepared synthetically by established standard methods (*e.g.* the phosphoroamidite method described by Beucage *et al.,* Tetrahedr. Lett., 22:1859-1869 [1981]; or the method described by Matthes *et al.,* EMBO J., 3:801-805 [1984]). In the phosphoroamidite method, oligonucleotides are synthesized (*e.g.*, in an automatic DNA synthesizer), purified, annealed, ligated and cloned in appropriate vectors.

In some embodiments of the present invention, the nucleotide sequences are either of mixed genomic and synthetic origin, mixed synthetic and cDNA origin or mixed genomic and cDNA origin, prepared by ligating fragments of synthetic, genomic or cDNA origin, in accordance with standard techniques. Each ligated fragment corresponds to various parts of the entire nucleotide sequence. In some embodiments, the DNA sequence is prepared by polymerase chain reaction (PCR) using specific primers, as known in the art.

In some embodiments, the nucleotide sequences described here and suitable for use in the methods and compositions described here include within them synthetic or modified nucleotides. A number of different types of modification to oligonucleotides are known in the art. These include, but are not limited to methylphosphonate and phosphorothioate backbones and/or the addition of acridine or polylysine chains at the 3' and/or 5' ends of the molecule. However, it is not intended that the present invention be limited to any particular method, as any suitable method known to those in the art for modifying nucleotide sequences find use in the present invention. In some embodiments, these modifications are performed in order to enhance the *in vivo* activity and/or life span of nucleotide sequences.

In some preferred embodiments, the present invention provides nucleotide sequences and methods for using nucleotide sequences that are complementary to the sequences presented herein, as well as derivatives and/or fragments of these sequences.

In some embodiments, the polynucleotides of the present invention find use in the production of primers and/or probes. Thus, in some embodiments, the polynucleotide sequences are used to produce PCR primers, primers for other amplification methods as known in the art, labeled probes, and/or for cloning methods. In preferred embodiments, these primers, probes and other fragments are at least 15, preferably at least 20, and in some more preferable embodiments, at least 25, 30 or 40 nucleotides. In addition, these primers, probes and fragments are encompassed by the term "polynucleotide."

In some embodiments, polynucleotides such as DNA polynucleotides and probes are produced recombinantly, while in other embodiments they are produced synthetically. In additional embodiments, these sequences are cloned using standard methods. In general, primers

are produced by synthetic means, involving a stepwise manufacture of the desired nucleic acid sequence one nucleotide at a time. Techniques for accomplishing this using automated techniques are readily available in the art. However, it is not intended that the present invention be limited to production of polynucleotides using any particular method, as any suitable method known to those in the art finds use in the present invention.

In some embodiments, longer polynucleotides are generally be produced using recombinant means, for example using PCR cloning techniques, as known in the art. In such embodiments, the primers are typically designed to contain suitable restriction enzyme recognition sites so that the amplified DNA can be readily cloned into a suitable cloning vector. Preferably, the variant sequences are at least as biologically active as the sequences presented herein.

In some preferred embodiments, sequences that are provided that are complementary to the compound or sequences that are capable of hybridizing to the nucleotide sequences of the compounds (including complementary sequences of those presented herein), as well as nucleotide sequences that are complementary to sequences that can hybridize to the nucleotide sequences of the compounds (including complementary sequences of those presented herein). In some preferred embodiments, polynucleotide sequences that are capable of hybridizing to the nucleotide sequences presented herein under conditions of intermediate to maximal stringency are provided.

In some preferred embodiments, nucleotide sequences that can hybridize to the nucleotide sequence of the compound nucleic acid, or the complement thereof, under stringent conditions (*e.g.*, 50°C and 0.2xSSC) are provided. More preferably, the nucleotide sequences can hybridize to the nucleotide sequence of the compound, or the complement thereof, under more highly stringent conditions (*e.g.* 65°C and 0.1xSSC).

In some embodiments, it is desirable to mutate the sequence in order to prepare a compound. Accordingly, in some embodiments, mutants are prepared from the compounds provided herein. In some embodiments, mutations are introduced using synthetic oligonucleotides. These oligonucleotides contain nucleotide sequences flanking the desired mutation sites. Various methods known in the art find use in this embodiment (*See e.g.*, Morinaga *et al.*, Biotechnol., 2:646-649 [1984]; Nelson and Long, Anal. Biochem., 180:147-151 [1989]; and Sarkar and Sommer, Biotechn., 8:404-407 [1990]). However, additional methods find use in the present invention and it is not intended that the present invention be limited to any particular method.

In some preferred embodiments, the sequences used in the methods and compositions described herein is a recombinant sequence (*i.e.*, a sequence that has been prepared using recombinant DNA techniques produced using any suitable method known in the art.

In additional embodiments, the present invention provides vectors comprising the compound, cells comprising the compound, and methods of expressing the compound. In some embodiments, the nucleotide sequences used in the methods and compositions described herein are incorporated into a recombinant replicable vector. In some embodiments, the vector is used to replicate and express the nucleotide sequence, in enzyme form, in and/or from a compatible host cell. In some embodiments, expression is controlled using control sequences (*e.g.*, regulatory sequences). In some embodiments, proteins produced by a host cell by expression of the nucleotide sequence are secreted (*i.e.*, into the growth medium), while in other embodiments, the proteins are contained intracellularly within the host cell. In some embodiments, the coding sequences are designed to include signal sequences which direct secretion of the substance coding sequences through a particular prokaryotic or eukaryotic cell membrane. In further embodiments, polynucleotides are incorporated into a recombinant replicable vector. In additional embodiments, the vector is used to replicate the nucleic acid in a compatible host cell. In preferred embodiments, the vector comprising the polynucleotide sequence is transformed into a suitable host cell. While any suitable host finds use in the present invention, in some preferred embodiments, the hosts are selected from the group consisting of bacterial, yeast, insect, fungal, and mammalian cells.

In some embodiments, compounds and their polynucleotides are expressed by introducing a polynucleotide into a replicable vector, introducing the vector into a compatible host cell, and growing the host cell under conditions which bring about replication of the vector. In some embodiments, the vector is recovered from the host cell.

In additional embodiments, the compound nucleic acid is operatively linked to transcriptional and translational regulatory elements active in the host cell. In some embodiments, the compound nucleic acid also encodes a fusion protein comprising at least one signal sequence (*e.g.*, those derived from the glucoamylase gene from *Schwanniomyces occidentalis,* α-factor mating type gene from *Saccharomyces cerevisiae* and the TAKA-amylase from *Aspergillus oryzae*). In further alternative embodiments, the compound nucleic acid encodes a fusion protein comprising a membrane binding domain.

In some preferred embodiments, the compound is expressed at the desired levels in a host organism using an expression vector. It is contemplated that any expression vector comprising a compound nucleic acid that is capable of expressing the gene encoding the compound nucleic acid in the selected host organism will find use in the present invention. The choice of vector depends upon the host cell into which it is to be introduced. Thus, in some embodiments, the vector is an autonomously replicating vector (*i.e.*, a vector that exists as an episomal entity, the replication of which is independent of chromosomal replication, such as, for example, a plasmid, a bacteriophage or an episomal element, a minichromosome or an artificial chromosome).

Alternatively, in some embodiments, the vector integrates into the host cell genome and replicates together with the chromosome.

In some preferred embodiments, the expression vector includes the components of a cloning vector, including but not limited to such components as an element that permits autonomous replication of the vector in the selected host organism and one or more phenotypically detectable markers for selection purposes. In preferred embodiments, the expression vector further comprises control nucleotide sequences encoding a promoter, operator, ribosome binding site, translation initiation signal, and optionally, a repressor gene or one or more activator genes. Additionally, in some embodiments, the expression vector comprises a sequence coding for an amino acid sequence capable of targeting the compound to a host cell organelle such as a peroxisome or to a particular host cell compartment. Such a targeting sequence includes but is not limited to the sequence SKL. For expression under the direction of control sequences, the nucleic acid sequence encoding the compound is operably linked to the control sequences in proper manner with respect to expression.

In some preferred embodiments, the polynucleotide in a vector is operably linked to a control sequence that is capable of providing for the expression of the coding sequence by the host cell (*i.e.*, the vector is an expression vector). In some embodiments, the control sequences are modified (*e.g.*, by the addition of further transcriptional regulatory elements) in order to make the level of transcription directed by the control sequences more responsive to transcriptional modulators. In some preferred embodiments, the control sequences comprise promoters.

In some preferred embodiments of the vectors, the nucleic acid sequence encoding for the compound is operably combined with a suitable promoter sequence. The promoter can be any DNA sequence having transcription activity in the host organism of choice and can be derived from genes that are homologous or heterologous to the host organism. Examples of suitable promoters for directing the transcription of the modified nucleotide sequence, such as compound nucleic acids, in a bacterial host include, but are not limited to the promoter of the *lac* operon of *E. coli,* the *Streptomyces coelicolor* agarase gene *dagA* promoters, the promoters of the *Bacillus licheniformis* α-amylase gene (*amyL*), the aprE promoter of *Bacillus subtilis,* the promoters of the *Bacillus stearothermophilus* maltogenic amylase gene (*amyM*), the promoters of the *Bacillus amyloliquefaciens* α-amylase gene (*amyQ*), the promoters of the *Bacillus subtilis xylA and xylB* genes and a promoter derived from a *Lactococcus* sp.-derived promoter including the P170 promoter. When the gene encoding the compound is expressed in a bacterial species such as *E. coli,* a suitable promoter can be selected, for example, from a bacteriophage promoter including a T7 promoter and a phage lambda promoter. For transcription in a fungal species, examples of useful promoters are those derived from the genes encoding the *Aspergillus oryzae* TAKA amylase, *Rhizomucor miehei* aspartic proteinase, *A. niger* neutral α-amylase, *A. niger* acid stable

α-amylase, *A. niger* glucoamylase, *Rhizomucor miehei* lipase, *A. oryzae* alkaline protease, *A. oryzae* triose phosphate isomerase, and *A. nidulans* acetamidase. Examples of suitable promoters for the expression in a yeast species include but are not limited to the Gal 1 and Gal 10 promoters of *Saccharomyces cerevisiae* and the *Pichia pastoris* AOX1 *or* AOX2 promoters.

Examples of suitable bacterial host organisms are Gram positive species, including, but not limited to members of the *Bacillaceae*, (*e.g., B. subtilis, B. licheniformis, B. lentus, B. brevis, B. stearothermophilus, B. alkalophilus, B. amyloliquefaciens, B. coagulans, B. lautus, B. megaterium* and *B. thuringiensis*), *Streptomyces* species (*e.g., S. murinus* and *S. lividans*) lactic acid bacteria (*e.g., Lactococcus* spp. such as *Lactococcus lactis*; *Lactobacillus* spp. including *Lactobacillus reuteri*; *Leuconostoc spp.; Pediococcus* spp.; and *Streptococcus spp.* Alternatively, strains of Gram-negative species belonging to *Enterobacteriaceae* (*e.g., E. coli*) or members of the *Pseudomonadaceae* find use in the present invention.

In some embodiments, a suitable yeast host organism is selected from various biotechnologically useful yeasts species, including but not limited to *Pichia sp., Hansenula* sp or *Kluyveromyces, Yarrowinia , Saccharomyces* (*e.g., Saccharomyces cerevisiae*), *Schizosaccharomyce* (*e.g., S. pombe*). In some embodiments, strains of the methylotrophic yeast species *Pichia pastoris* are used as the host organism, while in other embodiments, the host organism is a *Hansenula* species. Suitable host organisms among filamentous fungi include species of *Aspergillus* (*e.g., A. niger, A. oryzae, A. tubigensis, A. awamori* and *Aspergillus nidulans*). Alternatively, strains of *Fusarium* species (*e.g. F. oxysporum*) and *Rhizomucor* (*e.g., Rhizomucor miehei*) find used as the host organism. Additional suitable strains include, but are not limited to *Thermomyces* and *Mucor* species.

In some preferred embodiments, host cells comprising polynucleotides are used to express polypeptides, such as the compounds disclosed herein, fragments, homologues, variants or derivatives thereof. Host cells are cultured under suitable conditions which allow expression of the proteins. In some embodiments, expression of the polypeptides is constitutive (*i.e.*, the peptides are continually produced), while in other embodiments, expression is inducible. In the case of inducible expression, protein production is initiated when required by addition of an inducer substance to the culture medium (*e.g.*, dexamethasone or IPTG). Polypeptides can be extracted from host cells by a variety of techniques known in the art, including enzymatic, chemical, and/or osmotic lysis and physical disruption. Indeed, it is not intended that the present invention be limited to any particular means of harvesting expressed polypeptides.

In alternative embodiments, polypeptides are produced recombinantly in any suitable (including commercially available) *in vitro* cell-free system, such as the TnT™ (Promega) rabbit reticulocyte system.

In additional preferred embodiments, the present invention provides cosmetic and/or pharmaceutical compositions comprising at least one polypeptide or peptide, as set forth herein, and a physiologically acceptable carrier or excipient. Preferably, the compound is present in an amount of about 0.0001% to about 5% by weight, based on the total weight of the composition. Also preferably, the compound is present in an amount of about 0.001% to about 0.5% by weight based on the total weight of the composition. The composition may be in the form of an emulsified vehicle, such as a nutrient cream or lotion, a stabilized gel or dispersion system, a treatment serum, a liposomal delivery system, a topical pack or mask, a surfactant-based cleansing system such as a shampoo or body wash, an aerosolized or sprayed dispersion or emulsion, a hair or skin conditioner, styling aid, or a pigmented product such as makeup. Preferably, the carrier is at least compound selected from the group consisting of water, propylene glycol, ethanol, propanol, glycerol, butylene glycol and polyethylene glycol.

In some liposomal embodiments, the liposomes comprise water and one or more ingredients capable of forming lipid bilayer vesicles that can hold one or more functional or active ingredient(s). Non-limiting examples of ingredients capable of forming lipid bilayer vesicles include: phospholipids, hydrogenated phosphatidylcholine, lecithin, cholesterol and sphingolipids. Non-limiting examples of functional or active ingredients that can be delivered via liposomes include: vitamins and their derivatives, antioxidants, proteins and peptides, keratolytic agents, bioflavinoids, terpenoids, phytochemicals, and extracts of plant, marine or fermented origin. In a preferred embodiment, the composition further comprises a skin care or hair care active. Active ingredients can include any of a wide variety of ingredients such as are known in the art. (*See e.g.*, McCutcheon's Functional Materials, North American and International Editions, (2003), published by MC Publishing Co.). Preferably, such actives include but are not limited to antioxidants, such as tocopheryl and ascorbyl derivatives, bioflavinoids, terpenoids, synthetics and the like, vitamins and vitamin derivatives, hydroxyl- and polyhydroxy acids and their derivatives, such as AHAs and BHAs and their reaction products, peptides and polypeptides and their derivatives, such as glycopeptides and lipophilized peptides, heat shock proteins and cytokines, enzymes and enzymes inhibitors and their derivatives, such as proteases, MMP inhibitors, catalases, glucose oxydase and superoxide dismutase, amino acids and their derivatives, bacterial, fungal and yeast fermentation products and their derivatives, including mushrooms, algae and seaweed and their derivatives, phytosterols and plant and plant part extracts and their derivatives and phospholipids and their derivatives, anti-dandruff agents such as zinc pyrithione and delivery systems containing them, as provided herein and/or known in the art.

In some preferred embodiments, the skin care active is selected from the group consisting of a Vitamin B3 component, panthenol, Vitamin E, Vitamin E acetate, retinol, retinyl propionate,

retinyl palmitate, retinoic acid, Vitamin C, theobromine, alpha-hydroxyacid, farnesol, phytrantriol, salicylic acid, palmityl peptapeptide-3 and mixtures thereof. In some preferred embodiments, the Vitamin B3 component is niacinamide. In some embodiments, the compositions provided herein comprise a skin care active at a level from about 0.0001% to about 20%, preferably from about 0.001% to about 5%, more preferably from about 0.01% to about 2%, by weight.

Exemplary derivatives of the foregoing vitamin B_3 compounds include nicotinic acid esters, including non-vasodilating esters of nicotinic acid, nicotinyl amino acids, nicotinyl alcohol esters of carboxylic acids, nicotinic acid N-oxide and niacinamide N-oxide. Suitable esters of nicotinic acid include nicotinic acid esters of C_1-C_{22}, preferably C_1-C_{16}, more preferably C_1-C_6 alcohols. In these embodiments, the alcohols are suitably straight-chain or branched chain, cyclic or acyclic, saturated or unsaturated (including aromatic), and substituted or unsubstituted. The esters are preferably non-vasodilating.

Non-vasodilating esters of nicotinic acid include tocopherol nicotinate and inositol hexanicotinate; tocopherol nicotinate are preferred. A more complete description of vitamin B_3 compounds is provided in WO 98/22085. Preferred vitamin B_3 compounds include niacinamide and tocopherol nicotinate.

In additional embodiments, the skin care active comprises at least one retinoid. The retinoid is preferably retinol, retinol esters (*e.g.*, C_2 - C_{22} alkyl esters of retinol, including retinyl palmitate, retinyl acetate, retinyl proprionate), retinal, and/or retinoic acid (including all-trans retinoic acid and/or 13-cis-retinoic acid), more preferably retinoids other than retinoic acid. These compounds are well known in the art and are commercially available from a number of sources (*e.g.*, Sigma and Boehringer Mannheim). Preferred retinoids include retinol, retinyl palmitate, retinyl acetate, retinyl proprionate, retinal, retinoic acid and combinations thereof. More preferred are retinol, retinoic propionate, retinoic acid and retinyl palmitate. In some embodiments, the retinoid is included as a substantially pure material, while in other embodiments, it is provided as an extract obtained by suitable physical and/or chemical isolation from natural (*e.g.*, plant) sources. When a retinoid is included in the compositions herein, it preferably comprises from about 0.005% to about 2%, preferably from about 0.01% to about 1% retinoid. Retinol is preferably used in an amount of from about 0.01% to about 0.15%; retinol esters are preferably used in an amount of from about 0.01% to about 2% (e.g., about 1%).

In some embodiments, the compositions of the present invention comprise safe and effective amounts of a dermatologically acceptable carrier that is suitable for topical application to the skin or hair within which the essential materials and optional other materials are incorporated to enable the essential materials and optional components to be delivered to the skin

or hair at an appropriate concentration. Thus, in some embodiments, the carrier acts as a diluent, dispersant, solvent or the like for the essential components, ensuring that these components can be applied and distributed evenly over the selected target at an appropriate concentration.

In further embodiments, an effective amount of one or more compounds described herein is also be included in compositions to be applied to keratinous materials such as nails and hair, including but not limited to those useful as hair spray compositions, hair styling compositions, hair shampooing and/or conditioning compositions, compositions applied for the purpose of hair growth regulation and compositions applied to the hair and scalp for the purpose of treating seborrhoea, dermatitis and/or dandruff.

In yet additional embodiments, an effective amount of one or more compounds described herein is included in compositions suitable for topical application to the skin or hair. These compositions are provided in any suitable form, including but not limited to creams, lotions, gels, suspensions dispersions, microemulsions, nanodispersions, microspheres, hydrogels, emulsions (*e.g.*, oil-in-water and water-in-oil, as well as multiple emulsions), and multilaminar gels and the like (*See e.g.*, Schlossman *et al.*, The Chemistry and Manufacture of Cosmetics, [1998], incorporated by reference, herein). In some embodiments, the compositions are formulated as aqueous or silicone compositions, while in other embodiments they are formulated as emulsions of one or more oil phases in an aqueous continuous phase (or an aqueous phase in an oil phase).

The type of carrier utilized in the present invention depends on the type of product form desired for the composition. The carrier can be solid, semi-solid or liquid. Suitable carriers include liquids, semi-solids (*e.g.*, creams, lotions, gels, sticks, ointments, and pastes), sprays and mousses. Preferably the carrier is in the form of a lotion, cream or a gel, more preferably one which has a sufficient thickness or yield point to prevent the particles from sedimenting. In some embodiments, the carrier is inert, while in other embodiments it provides dermatological benefits. In some embodiments, the carrier is applied directly to the skin and/or hair, while in other embodiments, it is applied via a woven or non-woven wipe or cloth. In yet other embodiments, it is in the form of a patch, mask or wrap. In still further embodiments, it is aerosolized or otherwise sprayed or pumped onto the skin and/or hair. The carrier chosen is physically and chemically compatible with the essential components described herein, and should not unduly impair stability, efficacy or other use benefits associated with the compositions of the present invention.

Preferred carriers contain a dermatologically acceptable, hydrophilic diluent. Suitable hydrophilic diluents include water, organic hydrophilic diluents such as $C_2 - C_{10}$, preferably $C_2 - C_6$, preferably, $C_3 - C_6$ monohydric alcohols and low molecular weight glycols and polyols, including propylene glycol, polyethylene glycol polypropylene glycol, glycerol, butylene glycol, 1,2,4-butanetriol, sorbitol esters, 1,2,6-hexametriol, pentylene glycol, hexylene glycol, sorbitol

esters, ethoxylated ethers, propoxylated ethers, and combinations thereof. The diluent is preferably liquid. Water is a preferred diluent. The composition preferably comprises at least about 20% of the hydrophilic diluent.

In some embodiments, suitable carriers also comprise an emulsion comprising a hydrophilic phase, especially an aqueous phase, and a hydrophobic phase (*e.g.*, a lipid, oil or oily material). As well known to those skilled in the art, the hydrophilic phase is dispersed in the hydrophobic phase, or vice versa, to form respectively hydrophilic or hydrophobic dispersed and continuous phases, depending on the composition of ingredients. The term "dispersed phase" is a term well-known to one skilled in the art of emulsion technology, used in reference to the phase which exists as small particles or droplets that are suspended in and surrounded by a continuous phase. The dispersed phase is also known as the internal or discontinuous phase. The emulsion may be or comprise (*e.g.*, in a triple or other multi-phase emulsion) an oil-in-water emulsion or a water-in-oil emulsion such as a water-in-silicone emulsion. Oil-in-water emulsions typically comprise from about 1% to about 60% (preferably about 1% to about 30%) of the dispersed hydrophobic phase and from about 1% to about 99% (preferably from about 10% to about 90%) of the continuous hydrophilic phase, while water-in-oil emulsions typically comprise from about 1% to about 98% (preferably from about 40% to about 90%) of the dispersed hydrophilic phase and from about 1% to about 50% (preferably about 1% to about 30%) of the continuous hydrophobic phase.

In further embodiments, the carrier also includes one or more components that facilitate penetration through the upper stratum corneum barrier to the lower levels of the skin. Examples of penetration enhancers include, but are not limited to, propylene glycol, azone, ethoxydiglycol, dimethyl isosorbide, urea, ethanol and dimethyl sulfoxide, as well as microemulsions, liposomes and nanoemulsions.

In some additional embodiments, the compositions of the present invention comprise humectants which are preferably present at a level of from about 0.01% to about 20%, preferably from about 0.1% to about 15% and preferably from about 0.5% to about 10%. Preferred humectants include, but are not limited to, compounds selected from polyhydric alcohols, sorbitol, glycerol, urea, betaine, D-panthenol, DL-panthenol, calcium pantothenate, royal jelly, panthetine, pantotheine, panthenyl ethyl ether, pangamic acid, pyridoxin, pantoyl lactose Vitamin B complex, sodium pyrrolidone carboxylic acid, hexane - 1, 2, 6, - triol, guanidine or its derivatives, and mixtures thereof.

Suitable polyhydric alcohols for use herein include, but are not limited to polyalkylene glycols and preferably alkylene polyols and their derivatives, including propylene glycol, dipropylene glycol, polypropylene glycol, polyethylene glycol and derivatives thereof, sorbitol, hydroxypropyl sorbitol, erythritol, threitol, pentaerythritol, xylitol, glucitol, mannitol, pentylene

glycol, hexylene glycol, butylene glycol (e.g., 1,3-butylene glycol), hexane triol (*e.g.*, 1,2,6-hexanetriol), trimethylol propane, neopentyl glycol, glycerine, ethoxylated glycerine, propane-1,3 diol, propoxylated glycerine and mixtures thereof. The alkoxylated derivatives of any of the above polyhydric alcohols are also suitable for use herein. Preferred polyhydric alcohols of the present invention are selected from glycerine, butylene glycol, propylene glycol, pentylene glycol, hexylene glycol, dipropylene glycol, polyethylene glycol, hexane triol, ethoxylated glycerine and propoxylated glycerine and mixtures thereof.

Suitable humectants useful herein are sodium 2-pyrrolidone-5-carboxylate (NaPCA), guanidine; glycolic acid and glycolate salts (*e.g.*, ammonium and quaternary alkyl ammonium); lactic acid and lactate salts (*e.g.*, ammonium and quaternary alkyl ammonium); aloe vera in any of its variety of forms (*e.g.*, aloe vera gel); hyaluronic acid and derivatives thereof (*e.g.*, salt derivatives such as sodium hyaluronate); lactamide monoethanolamine; acetamide monoethanolamine; urea; betaine, panthenol and derivatives thereof; and mixtures thereof.

In some embodiments, at least part (up to about 5% by weight of composition) of a humectant is incorporated into the compositions of the present invention in the form of an admixture with a particulate cross-linked hydrophobic acrylate or methacrylate copolymer, itself preferably present in an amount of from about 0.1% to about 10%, which can be added either to the aqueous or disperse phase. This copolymer is particularly valuable for reducing shine and controlling oil while helping to provide effective moisturization benefits and is described in further detail in WO96/03964, incorporated herein by reference.

In some embodiments, the oil-in-water and water-in-oil compositions of the present invention comprise from about 0.05% to about 20%, preferably from about 1% to about 15%, preferably from about 2% to about 10%, preferably from about 2% to about 5% of a dermatologically acceptable emollient. Emollients tend to lubricate the skin, increase the smoothness and suppleness of the skin, prevent or relieve dryness of the skin and/or protect the skin. Emollients are typically water-immiscible, oily or waxy materials and emollients can confer aesthetic properties to a topical composition. A wide variety of suitable emollients are known (*See e.g.*, Sagarin, Cosmetics, Science and Technology, 2nd Edition, Vol. 1, pp. 32-43 [1972]; and WO 00/24372), and find use herein, contains numerous examples of materials suitable as emollients. Additional emollients include, but are not limited to the following:

i) Straight and branched chain hydrocarbons having from about 7 to about 40 carbon atoms, such as mineral oils, dodecane, squalane, cholesterol, hydrogenated polyisobutylene, isohexadecane, isoeicosane, isooctahexacontane, isohexapentacontahectane, and the C_7-C_{40} isoparaffins, which are C_7-C_{40} branched hydrocarbons. Suitable branched chain hydrocarbons for use herein are selected from isopentacontaoctactane, petrolatum and mixtures thereof;

ii) C_1-C_{30} fatty acid esters of C_1-C_{30} carboxylic acids, C_{12-15} alkyl benzoates and of C_2-C_{30} dicarboxylic acids, *e.g.* isononyl isononanoate, isostearyl neopentanoate, isodecyl octanoate, isodecyl isononanoate, tridecyl isononanoate, myristyl octanoate, octyl pelargonate, octyl isononanoate, myristyl myristate, myristyl neopentanoate, myristyl octanoate, isopropyl myristate, myristyl propionate, isopropyl stearate, isopropyl isostearate, methyl isostearate, behenyl behenate, dioctyl maleate, diisopropyl adipate, and diisopropyl dilinoleate and mixtures thereof also find use in the present invention;

iii) C_1-C_{30} mono- and poly- esters of sugars and related materials. These esters are derived from a sugar or polyol moiety and one or more carboxylic acid moieties. Depending on the constituent acid and sugar, these esters can be in either liquid or solid form at room temperature. Examples include: glucose tetraoleate, the galactose tetraesters of oleic acid, the sorbitol tetraoleate, sucrose tetraoleate, sucrose pentaoleate, sucrose hexaoleate, sucrose heptaoleate, sucrose octaoleate, sorbitol hexaester. Other materials include cottonseed oil or soybean oil fatty acid esters of sucrose. Other examples of such materials are described in WO 96/16636, incorporated by reference herein;

iv) Vegetable oils and hydrogenated vegetable oils. Examples of vegetable oils and hydrogenated vegetable oils include safflower oil, grapeseed oil, coconut oil, cottonseed oil, menhaden oil, palm kernel oil, palm oil, peanut oil, soybean oil, rapeseed oil, linseed oil, rice bran oil, pine oil, nut oil, sesame oil, sunflower seed oil, partially and fully hydrogenated oils from the foregoing sources and mixtures thereof;

v) Soluble or colloidally-soluble moisturizing agents. Examples include hyaluronic acid and chondroitin sulfate.

In some embodiments, the compositions of the present invention contain an emulsifier and/or surfactant, generally to help disperse and suspend the disperse phase within the continuous aqueous phase. A surfactant may also be useful if the product is intended for skin or hair cleansing. For convenience hereinafter, "emulsifiers" are encompassed by the term "surfactants." Thus, as used herein, the term "surfactant(s)" refers to surface active agents, whether used as emulsifiers or for other surfactant purposes such as skin cleansing. Known, including conventional surfactants find use in the present invention, provided that the selected agent is chemically and physically compatible with essential components of the composition and provides the desired characteristics (*See e.g.*, WO 00/24372). Suitable surfactants include non-silicone derived materials, silicone-derived materials, and mixtures thereof.

In further embodiments, the compositions of the present invention comprise preferably from about 0.05% to about 30%, more preferably from about 0.5% to 15%, and most preferably from about 1% to 10% of a surfactant or mixture of surfactants. The exact surfactant or

surfactant mixture chosen depends upon the pH of the composition, the other components present and the desired final product aesthetics.

Among the nonionic surfactants that are useful herein are those that can be broadly defined as condensation products of long chain alcohols (*e.g.*, C_{8-30} alcohols), with sugar or starch polymers (*e.g.*, glycosides). Other useful nonionic surfactants include the condensation products of alkylene oxides with fatty acids (*i.e.*, alkylene oxide esters of fatty acids). These materials have the general formula $RCO(X)_nOH$ wherein R is a C_{10-30} alkyl group, X is $-OCH_2CH_2-$ (*i.e.*, derived from ethylene glycol or oxide) or $-OCH_2CHCH_3-$ (*i.e.*, derived from propylene glycol or oxide) and n is an integer from about 6 to about 200. Other nonionic surfactants are the condensation products of alkylene oxides with 2 moles of fatty acids (*i.e.*, alkylene oxide diesters of fatty acids). These materials have the general formula $RCO(X)_nOOCR$ wherein R is a C_{10-30} alkyl group, X is $-OCH_2CH_2-$(*i.e.*, derived from ethylene glycol or oxide) or $-OCH_2CHCH_3-$(*i.e.*, derived from propylene glycol or oxide) and n is an integer from about 6 to about 100. In some embodiments, an emulsifier for use herein is preferably a fatty acid ester blend based on a mixture of sorbitan fatty acid ester and sucrose fatty acid ester, especially a blend of sorbitan stearate and sucrose cocoate. Further suitable examples include a mixture of cetearyl alcohols and cetearyl glucosides. However, it is not intended that the present invention be limited to any particular emulsifier, as various suitable emulsifiers are known in the art.

In additional embodiments, the hydrophilic surfactants useful herein alternatively or additionally include any of a wide variety of cationic, anionic, zwitterionic, and amphoteric surfactants such as are known in the art (*See, e.g.*, McCutcheon's, Emulsifiers and Detergents, North American and International Editions, MC Publishing Co. [2003]; U.S. Patent No. 5,011,681 U.S. Patent No. 4,421,769; and U.S. Patent No. 3,755,560).

A variety of anionic surfactants are also useful herein (*See e.g.*, U.S. Patent No. 3,929,678). Exemplary anionic surfactants include, but are not limited to alkoyl isethionates (*e.g.*, C_{12} - C_{30}), alkyl and alkyl ether sulfates and salts thereof, alkyl and alkyl ether phosphates and salts thereof, alkyl methyl taurates (*e.g.*, C_{12} - C_{30}), and soaps (*e.g.*, substituted alkylamine and alkali metal salts, *e.g.*, sodium or potassium salts) of fatty acids.

Amphoteric and zwitterionic surfactants are also useful herein. Examples of preferred amphoteric and zwitterionic surfactants which find use in the compositions of the present invention are those which are broadly described as derivatives of aliphatic secondary and tertiary amines in which the aliphatic radical can be straight or branched chain and wherein one of the aliphatic substituents contains from about 8 to about 22 carbon atoms (preferably C_8 - C_{18}) and one contains an anionic water solubilizing group (*e.g.*, carboxy, sulfonate, sulfate, phosphate, or phosphonate). Examples, include but are not limited to alkyl imino acetates and

iminodialkanoates and aminoalkanoates, imidazolinium and ammonium derivatives. Other suitable amphoteric and zwitterionic surfactants are those selected from the group consisting of betaines, sultaines, hydroxysultaines, and branched and unbranched alkanoyl sarcosinates, and mixtures thereof.

In further embodiments, some emulsions of the present invention include a silicone containing emulsifier or surfactant. A wide variety of silicone emulsifiers find use herein. These silicone emulsifiers are typically organically modified organopolysiloxanes, also known to those skilled in the art as silicone surfactants. Useful silicone emulsifiers include, but are not limited to dimethicone copolyols. These materials are polydimethyl siloxanes which have been modified to include polyether side chains such as polyethylene oxide chains, polypropylene oxide chains, mixtures of these chains and polyether chains containing moieties derived from both ethylene oxide and propylene oxide. Other examples include alkyl-modified dimethicone copolyols (*i.e.*, compounds which contain C_2-C_{30} pendant side chains). Still other useful dimethicone copolyols include materials having various cationic, anionic, amphoteric, and zwitterionic pendant moieties.

In some embodiments, the compositions of the present invention comprise at least one polymeric thickening agent. The polymeric thickening agents useful herein preferably have a number average molecular weight of greater than about 20,000, more preferably greater than about 50,000, and most preferably greater than about 100,000. In some embodiments, the compositions of the present invention comprise from about 0.01% to about 10%, preferably from about 0.1% to about 8% and more preferably from about 0.2% to about 5% by weight of the composition of the polymeric thickening agent or mixtures thereof.

Preferred polymer thickening agents for use herein include, but are not limited to non-ionic thickening agents and anionic thickening agents or mixtures thereof. Suitable non-ionic thickening agents include, but are not limited to polyacrylamide polymers, crosslinked poly(N-vinylpyrrolidones), polysaccharides, natural or synthetic gums, polyvinylpyrrolidone and polyvinylalcohol. Suitable anionic thickening agents include, but are not limited to acrylic acid/ethyl acrylate copolymers, carboxyvinyl polymers and crosslinked copolymers of alkyl vinyl ethers and maleic anhydride. Commercially available thickeners (*e.g.*, Carbopol; Noveon) find use in some embodiments of the present invention. Suitable Carbopol resins may be hydrophobically modified, and other suitable resins are described in WO98/22085, or mixtures thereof.

In some embodiments, the present compositions comprise at least one silicone oil phase. Silicone oil phase(s) generally comprises from about 0.1% to about 20%, preferably from about 0.5% to about 10%, and more preferably from about 0.5% to about 5%, of the composition. The silicone oil phase preferably comprises one or more silicone components.

In some embodiments, silicone components are fluids, including straight chain, branched and cyclic silicones. Suitable silicone fluids useful herein include silicones inclusive of polyalkyl siloxane fluids, polyaryl siloxane fluids, cyclic and linear polyalkylsiloxanes, polyalkoxylated silicones, amino and quaternary ammonium modified silicones, polyalkylaryl siloxanes or a polyether siloxane copolymer and mixtures thereof. Volatile, as well as non-volatile silicone fluids find use herein. Silicone fluids generally have an average molecular weight of less than about 200,000. In preferred embodiments, suitable silicone fluids have a molecular weight of about 100,000 or less, preferably about 50,000 or less, and more preferably about 10,000 or less. Preferably the silicone fluid is selected from silicone fluids having a weight average molecular weight in the range from about 100 to about 50,000 and preferably from about 200 to about 40,000. Typically, silicone fluids have a viscosity ranging from about 0.65 to about 600,000 mm^2s^{-1}, preferably from about 0.65 to about 10,000 $mm^2.s^{-1}$ at 25°C. The viscosity can be measured by means of a glass capillary viscometer as set forth in Dow Corning Corporate Test Method CTM0004, July 29, 1970. Suitable polydimethyl siloxanes that can be used herein include commercially available compounds (*e.g.*, from the General Electric Company and Dow Corning). Also useful are essentially non-volatile polyalkylarylsiloxanes, for example, polymethylphenylsiloxanes, having viscosities of about 0.65 to 30,000 mm^2s^{-1} at 25°C (General Electric Company or from Dow Corning). Cyclic polydimethylsiloxanes suitable for use herein are those having a ring structure incorporating from about 3 to about 7 $(CH_3)_2SiO$ moieties, preferably about 5 or more.

In additional embodiments, silicone gums find use herein. In some preferred embodiments, a silicone oil phase comprises a silicone gum or a mixture of silicones including the silicone gum. Typically, silicone gums have a viscosity at 25°C in excess of about 1,000,000 mm^2s^{-1}. The silicone gums include dimethicones as known in the art (*See e.g.*, U.S. Pat. No. 4,152,416; and Noll, Chemistry and Technology of Silicones, Academic Press, New York [1968]). Silicone gums such as those described in General Electric Silicone Rubber Product Data Sheets SE 30, SE 33, SE 54 and SE 76, also find use in the present invention. Specific examples of silicone gums include polydimethylsiloxane, (polydimethylsiloxane)(methylvinylsiloxane) copolymer, poly(dimethylsiloxane)(diphenyl)(methylvinylsiloxane) copolymer and mixtures thereof. Preferred silicone gums for use herein are silicone gums having a molecular weight of from about 200,000 to about 4,000,000 selected from dimethiconol, dimethicone copolyol, dimethicone and mixtures thereof.

In some embodiments, a silicone phase herein preferably comprises a silicone gum incorporated into the composition as part of a silicone gum-fluid blend. When the silicone gum is incorporated as part of a silicone gum-fluid blend, the silicone gum preferably constitutes from

about 5% to about 40%, especially from about 10% to 20% by weight of the silicone gum-fluid blend. Suitable silicone gum-fluid blends herein are mixtures consisting essentially of:

(i) a silicone having a molecular weight of from about 200,000 to about 4,000,000 selected from dimethiconol, fluorosilicone and dimethicone and mixtures thereof; and

(ii) a carrier which is a silicone fluid, the carrier having a viscosity from about 0.65 mm^2s^{-1} to about 100 mm^2s^{-1},

wherein the ratio of i) to ii) is from about 10:90 to about 20:80 and wherein said silicone gum-based component has a final viscosity of from about 100 mm^2s^{-1} to about 100,000 mm^2s^{-1}, preferably from 500 mm^2s^{-1} to about 10,000 mm^2s^{-1}.

Further silicone components suitable for use in a silicone oil phase herein include crosslinked polyorganosiloxane polymers, optionally dispersed in a fluid carrier. In general, when present the crosslinked polyorganosiloxane polymers, together with its carrier (if present) comprises from about 0.1% to about 20%, preferably from about 0.5% to about 10%, and more preferably from about 0.5% to about 5% of the composition. Such polymers comprise polyorganosiloxane polymers crosslinked by a crosslinking agent (*See e.g.,* WO98/22085). Examples of suitable polyorganosiloxane polymers for use herein include, but are not limited to methyl vinyl dimethicone, methyl vinyl diphenyl dimethicone and methyl vinyl phenyl methyl diphenyl dimethicone.

Another class of silicone components suitable for use in a silicone oil phase herein includes polydiorganosiloxane-polyoxyalkylene copolymers containing at least one polydiorganosiloxane segment and at least one polyoxyalkylene segment (*See e.g.,* WO98/22085). Suitable polydiorganosiloxane-polyalkylene copolymers are available commercially under the tradenames BELSIL® from Wacker-Chemie GmbH. A particularly preferred copolymer fluid blend for use herein includes Dow Corning DC3225C which has the CTFA designation Dimethicone/Dimethicone copolyol.

In further embodiments, compositions of the present invention comprise an organic sunscreen. In some embodiments, suitable sunscreens have UVA absorbing properties, while others have UVB absorbing properties, and still others comprise a mixture thereof. The exact amount of the sunscreen active varies, depending upon the desired Sun Protection Factor (*i.e.*, the "SPF") of the composition, as well as the desired level of UV protection. SPF is a commonly used measure of photoprotection of a sunscreen against erythema. The SPF is defined as a ratio of the ultraviolet energy required to produce minimal erythema on protected skin to that required to produce the same minimal erythema on unprotected skin in the same individual. Amounts of the sunscreen used are preferably from about 2% to about 20%, and more preferably from about 4% to about 14%. Suitable sunscreens include, but are not limited to those approved for use in the United States, Japan, Europe and Australia. The compositions of the present invention

preferably comprise an SPF of about 2 to about 30, preferably about 4 about 30, and more preferably about 4 to about 15.

In some embodiments, the compositions of the present invention may one or more UVA absorbing sunscreen actives that absorb UV radiation having a wavelength of from about 320nm to about 400nm. Suitable UVA absorbing sunscreen actives include, but are not limited to dibenzoylmethane (*See e.g.*, Lowe and Shaath (eds.), Sunscreens: Development, Evaluation, and Regulatory Aspects, Marcel Dekker, Inc.) derivatives, anthranilate derivatives such as methylanthranilate and homomethyl, 1-N-acetylanthranilate, and mixtures thereof. The UVA absorbing sunscreen active is preferably present in an amount sufficient to provide broad spectrum UVA protection either independently, or in combination with, other UV protective actives which may be present in the composition.

Suitable UVA sunscreen actives include dibenzoylmethane sunscreen actives and their derivatives. They include, but are not limited to, those selected from 2-methyldibenzoylmethane, 4-methyldibenzoylmethane, 4-isopropyldibenzoylmethane, 4-tert-butyldibenzoylmethane, 2, 4-dimethyldibenzoylmethane, 2, 5-dimethyldibenzoylmethane, 4, 4'-diisopropylbenzoylmethane, 4-(1, 1-dimethylethyl)-4'-methoxydibenzoylmethane, 2-methyl-5-isopropyl-4'-methoxydibenzoylmethane, 2-methyl-5-tert-butyl-4'-methoxy-dibenzoylmethane, 2, 4-dimethyl-4'-methoxydibenzoylmethane, 2, 6-dimethyl-4'-tert-butyl-4'methoxydibenzoylmethane, and mixtures thereof. Preferred dibenzoyl sunscreen actives include those selected from 4-(1, 1-dimethylethyl)-4'-methoxydibenzoylmethane, 4-isopropyldibenzoylmethane, and mixtures thereof. A preferred sunscreen active is 4-(1, 1-dimethylethyl)-4'-methoxydibenzoylmethane.

The sunscreen active 4-(1, 1-dimethylethyl)-4'-methoxydibenzoylmethane, which is also known as butyl methoxydibenzoylmethane or "avobenzone," is commercially available under the names of Parsol® 1789 from Givaudan Roure (International) S. A., and Eusolex® 9020 from Merck & Co., Inc. The sunscreen 4-isoproplydibenzoylmethane, which is also known as isopropyldibenzoylmethane, is commercially available from Merck under the name of Eusolex® 8020.

In some embodiments, the compositions of the present invention further include one or more UVB sunscreen actives that absorb(s) UV radiation having a wavelength of about 290nm to about 320nm. The compositions comprise an amount of the UVB sunscreen active that is safe and effective in providing UVB protection either independently, or in combination with, other UV protective actives which may be present in the compositions. The compositions comprise from about 0.1% to about 20%, preferably from about 0.1% to about 12%, and more preferably from about 0.5% to about 8% by weight, of each UVB absorbing organic sunscreen, or as mandated by the relevant regulatory authority(s).

A variety of UVB sunscreen actives are suitable for use herein (See e.g., U.S. Pat No. 5,087,372; U.S. Pat.No. 5,073,371; U.S. Pat. No. 5,073,372; U.S. Pat. No. 4,937,370; and U.S. Pat. No. 4,999,186). Preferred UVB sunscreen actives are selected from 2-ethylhexyl-2-cyano-3, 2-ethylhexyl N,N-dimethyl-p-aminobenzoate, p-aminobenzoic acid, oxybenzone, homomenthyl salicylate, octyl salicylate, 4,4'-methoxy-t-butyldibenzoylmethane, 4-isopropyl dibenzoylmethane, 3-benzylidene camphor, 3-(4-methylbenzylidene) camphor, 3 -diphenylacrylate, 2-phenyl-benzimidazole-5-sulphonic acid (PBSA), cinnamate esters and their derivatives such as 2-ethylhexyl-p-methoxycinnamate, salicylate esters and their derivatives such as triethanolamine salicylate, ethylhexyl salicylate, octyldimethyl para-aminobenzoic acid, camphor derivatives and their derivatives, and mixtures thereof. Preferred organic sunscreen actives include 2-ethylhexyl-2-cyano-3, 3-diphenylacrylate, 2-phenyl-benzimidazole-5-sulphonic acid (PBSA), octyl-p-methoxycinnamate, and mixtures thereof. Salt and acid neutralized forms of the acidic sunscreens are also useful herein.

In some embodiments, at least one agent is added to any of the compositions useful in the present invention to stabilize the UVA sunscreen to prevent it from photo-degrading on exposure to UV radiation and thereby maintaining its UVA protection efficacy. A wide range of compounds are reported to have these stabilizing properties and should be chosen to complement both the UVA sunscreen and the composition as a whole (*See e.g.*, U.S. Pat. Nos 5,972,316; 5,968,485; 5,935,556; 5,827,508; and WO 00/06110). Preferred examples of stabilizing agents for use in the present invention include 2-ethylhexyl-2-cyano-3, 3-diphenylacrylate, ethyl-2-cyano-3, 3-diphenylacrylate, 2-ethylhexyl-3, 3-diphenylacrylate, ethyl-3, 3-bis(4-methoxyphenyl)acrylate, diethylhexyl 2,6 napthalate and mixtures thereof (Symrise Chemical Company).

In some embodiments, at least one agent is added to any of the compositions useful in the present invention to improve the skin substantivity of those compositions, particularly to enhance their resistance to being washed off by water or rubbed off. Examples include, but are not limited to, acrylates/C_{12-22} alkylmethacrylate copolymer, acrylate/acrylate copolymer, dimethicone, dimethiconol, graft-copoly (dimethylsiloxane/i-butyl methacrylate), lauryl dimethicone, PVP/Hexadecane copolymer, PVP/Eicosene copolymer, tricontanyl PVP and trimethoxysiloxysilicate.

In addition to organic sunscreens, in some embodiments, the compositions of the present invention additionally comprise inorganic physical sunblocks (*See e.g.*, TFA International Cosmetic Ingredient Dictionary, 6th Edition, pp. 1026-28 and 1103 [1995]; Sayre *et al.*, J. Soc. Cosmet. Chem., 41:103-109 [1990]; and Lowe *et al.*, *supra*). Preferred inorganic physical sunblocks include zinc oxide and titanium dioxide and mixtures thereof.

When used in preferred embodiments, the physical sunblocks are present in an amount such that the present compositions are transparent on the skin (*i.e.*, non-whitening), preferably from about 0.5% to about 20%, preferably from about 0.5% to about 10%, and more preferably from about 0.5% to 5% by weight. When titanium dioxide is used, it can have an anatase, rutile or amorphous structure. Manufacturers of micronized grade titanium dioxide and zinc oxide for sunscreen use include, but are not limited to Tayca Corporation, Uniqema, Shinetsu Chemical Corporation, Kerr-McGee, Nanophase, Nanosource, Sachtleben, Elementis, and BASF Corporation, as well as their distribution agents and those companies that further process the material for sunscreen use. Physical sunblock particles (*e.g.*, titanium dioxide and zinc oxide) can be uncoated or coated with a variety of materials including but not limited to amino acids, aluminum compounds such as alumina, aluminum stearate, aluminum laurate, and the like; carboxylic acids and their salts (*e.g.*, stearic acid and its salts); phospholipids, such as lecithin; organic silicone compounds; inorganic silicone compounds such as silica and silicates and mixtures thereof.

In some preferred embodiments, the composition of the present invention also include preservatives. Such preservatives include, but are not limited to pentylene glycol, ethylene diamine tetra acetate (EDTA) and its salts, chlorhexidine (and its diacetate, dihydrochloride, digluconate derivatives), 1,1,1-trichloro-2-methyl-2-propanol, parachloro metaxylenol, polyhexamethylenebiguanide hydrochloride, dehydroacetic acid, diazolidinyl urea, 2,4-dichlorobenzyl alcohol, 4,4-dimethyl-1,3-oxazolidine, formaldehyde, glutaraldehyde, dimethylidantoin, imidazolidinyl urea, 5-Chloro-2-methyl-4-isothiazolin-3-one, ortho-phenylphenol, 4-hydroxybenzoic acid ("paraben") and its methyl-, ethyl-, propyl-, isopropyl-, butyl-, isobutyl-esters,trichlosan, 2-phenoxyethanol, phenyl mercuric acetate, quaternium-15, salycilate, salicylic acid and its saltssorbic acid and its salts, iodopropanyl butylcarbamate zinc pyrithione, benzyl alcohol, 5-bromo-5nitro-1,3-dioxane, 2-bromo-2-nitropropane-1,3-diol, benzoic acid and its salts, sulfites, bisulfites, and benzalkonium chloride.

A variety of optional ingredients such as neutralizing agents, perfumes and perfume solubilizing agents, and coloring agents, also find use in some of the compositions herein. It is preferred that any additional ingredients enhance the skin softness/smoothness benefits of the product. In addition it is preferred that any such ingredients do not negatively impact the aesthetic properties of the product.

Neutralizing agents suitable for use in neutralizing acidic group containing hydrophilic gelling agents herein include sodium hydroxide, potassium hydroxide, ammonium hydroxide, monoethanolamine, diethanolamine, amino methyl propanol, tris-buffer and triethanolamine.

Other optional materials that find use in the present invention include any of the numerous functional and/or active ingredients known to those skilled in the art (*See e.g.*,

McCutcheon's Functional Materials, North American and International Editions, MC Publishing Co. [2003]) Non-limiting examples include keratolytic agents; soluble or colloidally-soluble moisturizing agents such as hyaluronic acid and chondroitin sulfate; vitamins such as vitamin A, vitamin C, vitamin E, vitamin K and derivatives thereof and building blocks thereof; phytantriol; fatty alcohols such as dodecatrienol; alpha and beta hydroxyacids; aloe vera; sphingosines and phytosphingosines, cholesterol; skin whitening agents; N-acetyl cysteine; coloring agents; Examples of alpha hydroxy acids include glycolic acid, lactic acid, malic acid, and citric acid (whether derived synthetically or from natural sources and whether used alone or in combination) and their esters or relevant buffered combinations. Other examples of alpha-hydroxy acids include: alpha-hydroxy ethanoic acid, alpha-hydroxyoctanoic acid, alpha-hydroxycaprylic acid, and hydroxycaprylic acid. Preferred examples of alpha hydroxy acids include glycolic acid and lactic acid. It is preferred that alpha hydroxy acids are used in levels of up to about 10%.

Optional materials include pigments that, where water-insoluble, contribute to and are included in the total level of oil phase ingredients. Pigments suitable for use in the compositions of the present invention can be organic and/or inorganic. Also included within the term "pigment" are materials having a low color or luster, such as matte finishing agents, light scattering agents, and formulation aids such as micas, seracites, and carbonate salts. Further examples of suitable pigments include titanium dioxide, iron oxides, zinc oxide, bismuth oxychloride (whether pre-dispersed and/or pre-coated or not) D&C dyes and lakes, FD&C colors, natural color additives such as carmine, and mixtures thereof. Depending upon the type of composition, a mixture of pigments is usually used in preferred embodiments of the present invention. Preferred pigments for use herein from the viewpoint of moisturization, skin feel, skin appearance and emulsion compatibility are treated pigments. In some embodiments, the pigments are treated with compounds, including but not limited to amino acids, silicones, lecithin and ester oils.

In preferred embodiments, the pH of the compositions herein is in the range from about 3.5 to about 10, preferably from about 4 to about 8, and more preferably from about 5 to about 7, wherein the pH of the final composition is adjusted by addition of acidic, basic or buffer salts as necessary, depending upon the composition of the forms and the pH-requirements of the compounds.

The compositions of the present invention are prepared by standard techniques well known to those skilled in the art. In general the aqueous phase and/or the oil phase are prepared separately, with materials of similar phase partitioning being added in any order. If the final product is an emulsion, the two phases are then combined with vigorous stirring and/or homogenization as necessary, to reduce the size of the internal phase droplets. Any ingredients in the formulation with high volatility, or which are susceptible to hydrolysis or decomposition at

high temperatures, are added with gentle stirring towards the end of the process, post emulsification if applicable. Dosage frequency and amount will depend upon the desired performance criteria.

In some embodiments of the present invention, method of decreasing TGFβ-1 and/or TGFβ-2 activity are provided. In these embodiments, the methods comprise applying to an organism in need thereof an effective amount of any one of the compounds set forth herein. These embodiments also include applications drawn to hair treatment, as well as other applications (*e.g.*, wound healing, treatment of proliferative diseases, etc). In additional preferred embodiments, the present invention provides compounds for treatment of an organism in need thereof.

Experimental

The following examples serve to illustrate certain preferred embodiments and aspects of the present invention and are not to be construed as limiting the scope thereof.

In the experimental disclosure which follows, the following abbreviations apply: PI (proteinase inhibitor), BBI (Bowman-Birk inhibitor), STI (Soybean Trypsin inhibitor); ppm (parts per million); M (molar); mM (millimolar); μM (micromolar); nM (nanomolar); mol (moles); mmol (millimoles); μmol (micromoles); nmol (nanomoles); gm (grams); mg (milligrams); μg (micrograms); pg (picograms); L (liters); ml and mL (milliliters); μl and μL (microliters); cm (centimeters); mm (millimeters); μm (micrometers); nm (nanometers); U (units); V (volts); MW (molecular weight); sec (seconds); min(s) (minute/minutes); hr(s) (hour/hours); °C (degrees Centigrade); QS (quantity sufficient); ND (not done); NA (not applicable); rpm (revolutions per minute); H_2O (water); dH_2O (deionized water); (HCl (hydrochloric acid); aa (amino acid); bp (base pair); kb (kilobase pair); kD (kilodaltons); cDNA (copy or complimentary DNA); DNA (deoxyribonucleic acid); ssDNA (single stranded DNA); dsDNA (double stranded DNA); dNTP (deoxyribonucleotide triphosphate); RNA (ribonucleic acid); $MgCl_2$ (magnesium chloride); NaCl (sodium chloride); w/v (weight to volume); v/v (volume to volume); *g* (gravity); OD (optical density); A_{405} (absorbance at 405 nm); Vmax (the maximum initial velocity of an enzyme catalyzed reaction); TGF-b sRII (soluble TGFβ-1 receptor); Dulbecco's phosphate buffered solution (DPBS); SOC (2% Bacto-Tryptone, 0.5% Bacto Yeast Extract, 10 mM NaCl, 2.5 mM KCl); Terrific Broth (TB; 12 g/l Bacto Tryptone, 24 g/l glycerol, 2.31 g/l KH_2PO_4, and 12.54 g/l K_2HPO_4); OD_{280} (optical density at 280 nm); OD_{600} (optical density at 600 nm); PAGE (polyacrylamide gel electrophoresis); PBS (phosphate buffered saline [150 mM NaCl, 10 mM sodium phosphate buffer, pH 7.2]); PBST (PBS+0.25% Tween® 20); PEG (polyethylene glycol); PCR (polymerase chain reaction); RT-PCR (reverse transcription PCR); SDS (sodium dodecyl sulfate); Tris (tris(hydroxymethyl)aminomethane); HEPES (N-[2-Hydroxyethyl]piperazine-

N-[2-ethanesulfonic acid]); HBS (HEPES buffered saline); SDS (sodium dodecylsulfate); bME, BME and βME (beta-mercaptoethanol or 2-mercaptoethanol); Tris-HCl (tris[Hydroxymethyl]aminomethane-hydrochloride); Tricine (N-[tris-(hydroxymethyl)-methyl]-glycine); CHES (2-(N-cyclo-hexylamino) ethane-sulfonic acid); TAPS (3-{[tris-(hydroxymethyl)-methyl]-amino}-propanesulfonic acid); CAPS (3-(cyclo-hexylamino)-propane-sulfonic acid; DMSO (dimethyl sulfoxide); DTT (1,4-dithio-DL-threitol); Glut and GSH (reduced glutathione); GSSG (oxidized glutathione); TCEP (Tris[2-carboxyethyl] phosphine); Tris-HCl (tris[Hydroxymethyl]aminomethane-hydrochloride); Ci (Curies) mCi (milliCuries); μCi (microCuries); TLC (thin layer achromatography); Ts (tosyl); Bn (benzyl); Ph (phenyl); Ms (mesyl); Et (ethyl), Me (methyl); Klenow (DNA polymerase I large (Klenow) fragment); rpm (revolutions per minute); EGTA (ethylene glycol-bis(ß-aminoethyl ether) N, N, N', N'-tetraacetic acid); EDTA (ethylenediaminetetracetic acid); bla (ß-lactamase or ampicillin-resistance gene); FBS and FCS (fetal calf serum); GE Healthcare (GE Healthcare, Chalfont St. Giles, United Kingdom); DNA2.0 (DNA2.0, Menlo Park, CA); OXOID (Oxoid, Basingstoke, Hampshire, UK); Megazyme (Megazyme International Ireland Ltd., Bray Business Park, Bray, Co., Wicklow, Ireland); Corning (Corning Life Sciences, Corning, NY); (NEN (NEN Life Science Products, Boston, MA); Pharma AS (Pharma AS, Oslo, Norway); Dynal (Dynal, Oslo, Norway); Bio-Synthesis (Bio-Synthesis, Lewisville, TX); ATCC (American Type Culture Collection, Rockville, MD); Gibco/BRL (Gibco/BRL, Grand Island , NY); Sigma (Sigma Chemical Co., St. Louis, MO); Pharmacia (Pharmacia Biotech, Pisacataway, NJ); NCBI (National Center for Biotechnology Information); Applied Biosystems (Applied Biosystems, Foster City, CA); Clontech (CLONTECH Laboratories, Palo Alto, CA); Difco (Difco Laboratories, Detroit, MI); Oxoid (Oxoid Inc., Ogdensburg, NY); GIBCO BRL or Gibco BRL (Life Technologies, Inc., Gaithersburg, MD); Millipore (Millipore, Billerica, MA); Bio-Rad (Bio-Rad, Hercules, CA); Invitrogen (Invitrogen Corp., San Diego, CA); NEB (New England Biolabs, Beverly, MA); Sigma (Sigma Chemical Co., St. Louis, MO); Pierce (Pierce Biotechnology, Rockford, IL); Takara (Takara Bio Inc. Otsu, Japan); Roche (Hoffmann-La Roche, Basel, Switzerland); EM Science (EM Science, Gibbstown, NJ); Qiagen (Qiagen, Inc., Valencia, CA); Biodesign (Biodesign Intl., Saco, Maine); Aptagen (Aptagen, Inc., Herndon, VA); Molecular Devices (Molecular Devices, Corp., Sunnyvale, CA); R&D Systems (R&D Systems, Minneapolis, MN); Stratagene (Stratagene Cloning Systems, La Jolla, CA); Marsh (Marsh Biosciences, Rochester, NY); Bio-Tek (Bio-Tek Instruments, Winooski, VT); (Biacore (Biacore, Inc., Piscataway, NJ); PeproTech (PeproTech, Rocky Hill, NJ); SynPep (SynPep, Dublin, CA); and Microsoft (Microsoft, Inc., Redmond, WA).

The peptides (TGFβ-1 and TGFβ-2) produced during the development of the present invention, some of which were used in the following Examples are provided below. In this Table, results for various assays are provided. In this Table, "Synthesized" refers to the peptide tested

alone, "BLA" refers to BLA-peptide fusions, and "BBI/BCE" refers to BBI/BCE-peptide fusions; "BV" refers to the BioVeris Assay (Example 17), and "CBA" refers to the cell-based assays (Example 16).

Table of Peptides

	Peptide Name	Sequence	SEQ ID NO:	Synthesized		BLA		BBI/ BCE	
				BV	CBA	BV	CBA	BV	CBA
TGF-b1	1A8	CVTTDWIEC	SEQ ID NO:2	-		-		-	
	1E11	CYYSQFHQC	SEQ ID NO:4	-		-		+/-	
	1A12	CPTLWTHMC	SEQ ID NO:6	-		-			
	PAN 10	QSACIVYYVGRKPKVECASSD	SEQ ID NO:18	-	-				
	PAN 11	QSACILYYIGKTPKIECASSD	SEQ ID NO:19	-	-				
	PAN 12	QSACILYYVGRTPKVECASSD	SEQ ID NO:20	-	-				
	PAZ 20	acetyl-LCPENDNVSPCY-cohn2	SEQ ID NO:21	-					
	T1-MM021	KHNVRLL	SEQ ID NO:22			-	+/-		
	T1-MM023	NDTPSYF	SEQ ID NO:23				-		
	T1-MM025	AKLYAGS	SEQ ID NO:24				-		
	T1-MM026	RGPAHSL	SEQ ID NO:25				-		
	T1-MM029	NSLAERR	SEQ ID NO:26				-		
	T1-MM032	HPLASPH	SEQ ID NO:27				-		
	T1-MM035	QPWNKLK	SEQ ID NO:28				-		
	T1-MM036	AWLr/Mipy	SEQ ID NO:29				-		
	T1-MM043	PTKPAQQ	SEQ ID NO:30						
	T1-MM045	PSLNRPQ	SEQ ID NO:31						
	T1-MM049	HHARQEW	SEQ ID NO:32						
	T1-MM055	RHHTPGP	SEQ ID NO:33						
	T1-MM057	ASAINPH	SEQ ID NO:34						
TGF-b2	1A3	CHGYDRAPC	SEQ ID NO:8						
	1E5	CFAPADQAC	SEQ ID NO:10						
	1G9	CIPSRFITC	SEQ ID NO:12						
	1A12	CHGHTKLAC	SEQ ID NO:14						
	1G4	CNGKSKLAC	SEQ ID NO:16						

EXAMPLE 1

Dermatological Composition

In this Example, various dermatological compositions comprising any of the compounds of the present invention are provided as follows.

MOISTURIZING BODYWASH (pH 7)

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Glycerin	4.0
PEG-6 Caprylic/Capric Glycerides	4.0
Palm Kernel Fatty acids	3.0
Sodium Laureth-3 Sulphate	45.0
Cocamide MEA	3.0
Sodium Lauroamphoacetate	25.0
Soybean Oil	10.0
Polyquaternium-10	0.70
Preservative, fragrance, color	QS
Compound	1000ppm

BODY WASH

RAW MATERIAL (INCI Designation)	pH 8	pH 6.5	pH 7
	Amount	Amount	Amount
Deionized water	QS	QS	QS
Sodium Laureth Sulphate	12	15	8
Cocamidopropyl Betaine	8	10	15
Decyl Glucoside	0	2	1
Polyquaternium-10	0.25	0	0
Polyquaternium-7	0	0	0.7
Preservative, fragrance, color	QS	QS	QS
Compound	250ppm	500ppm	1000ppm

BODY LOTION

RAW MATERIAL (INCI Designation)	pH 7 Amount	pH 7 Amount	pH 7.5 Amount	pH 7 Amount
Deionized Water	QS	QS	QS	QS
Glycerine	8	8	0	12
Isohexadecane	3	3	3	6
Niacinamide	0	3	5	6
Isopropyl Isostearate	3	3	3	3
Polyacrylamide (and) Isoparaffin (and) Laureth-7	3	3	3	3
Petrolatum	4	4	4	2
Nylon 12	2	2	2.5	2.5
Dimethicone	2	2	2.5	2.5
Sucrose Polycottonseed Oil	1.5	1.5	1.5	1.5
Stearyl Alcohol 97%	1	1	1	1
D Panthenol	1	1	1	1
DL-alphaTocopherol Acetate	1	1	1	1
Cetyl Alcohol 95%	0.5	0.5	0.5	1
Behenyl Alcohol	1	1	1	0.5
Cetearyl Alcohol (and) Cetearyl Glucoside	0.4	0.4	0.5	0.5
Stearic Acid	0.15	0.15	0.15	0.15
PEG-100-Stearate	0.15	0.15	0.15	0.15
Preservative, fragrance, color Compounds	QS 250 ppm	QS 500 ppm	QS 750 ppm	QS 1000ppm

ULTRA-HIGH MOISTURIZING EMULSION RAW MATERIAL (INCI Designation)	**pH 7 Amount**	**pH 7 Amount**
Deionized water	QS	QS
Glycerin	12	5
PEG 400	0	10
Niacinamide	5	7
Isohexadecane	5	5
Dimethicone	3	2
Polyacrylamide (and) Isoparaffin (and) Laureth-7	3	3
Isopropyl Isostearate	2	2
Polymethylsilsesquioxane	2	2
Cetyl Alcohol 95%	1	1
Sucrose polycottonseed oil	1	1
D-Panthenol	1	1
Tocopherol Acetate	1	1
Stearyl Alcohol 95%	0.5	0.5
Cetearyl Glucoside	0.5	0.5
Titanium dioxide	0.3	0.3
Stearic Acid	0.15	0.15
PEG-100-Stearate	0.15	0.15
Preservative, fragrance, color Compound	QS 250 ppm	QS 100 ppm

MOISTURIZING CREAM	pH 7	pH 7	pH 7.5
RAW MATERIAL (INCI Designation)	Amount	Amount	Amount
Deionized water	QS	QS	QS
Glycerine	3	5	10
Petrolatum	3	3	0
Cetyl Alcohol 95%	1.5	1.5	1
Dimethicone Copolyol	2	2	2
Isopropyl Palmitate	1	1	0.5
Carbopol 954 (Noveon)	0.7	0.7	0.7
Dimethicone (350cs)	1	1	1
Stearyl Alcohol 97%	0.5	0.5	1
Stearic acid	0.1	0.1	0.1
Peg-100-stearate	0.1	0.1	0.1
Titanium Dioxide	0.3	0.3	0.3
Preservative, color, fragrance	QS	QS	QS
Compound	50ppm	250ppm	1000ppm

5

LEAVE-ON HAIR CONDITIONER

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Isostearamidopropyl Morpholine Lactate	6.0
Hydroxyethylcellulose	1.0
Preservative, fragrance, color	QS
Compound	1000ppm

CREAM RINSE (pH 4)

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Behentrimonium Chloride	2.0
Trilaureth-4 Phosphate	1.5
Cetyl alcohol	2.0
Citric acid	QS
Preservative, fragrance, color	QS
Compound	1000ppm

NOURISHING HAIR CONDITIONER /TREATMENT (pH 6)

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Behentrimonium Methosulfate (and) Cetyl Alcohol	4.0
Wheat germ oil	1.0
Cetyl alcohol	0.5
Propylene glycol	5.0
PEG-60 Lanolin	1.0
Panthenol	2.0
Lupin amino acids	1.0
Cocodimonium Hydroxypropyl Hydrolyzed Wheat Protein	1.0
Fragrance, preservative, color	QS
Compound	1000ppm

CONDITIONING SHAMPOO

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Sodium Laureth Sulfate 30%	27.0
Cocamidopropyl Betaine	3.7
Coco-Glucoside (and) Glyceryl Oleate	5.0
Coco-Glucoside (and) Glycol Distearate (and) Glycerine	3.0
Guar Hydroxypropyl Trimonium Chloride	0.1
Laureth-2	1.55
Fragrance, preservative, color	QS
Compound	1000ppm

ANTI-DANDRUFF SHAMPOO

RAW MATERIAL (INCI Designation)	Amount
Deionized Water	QS
Magnesium Aluminum Silicate	1.0
Hydroxypropyl Methylcellulose	0.8
Sodium Olefin Sulfate 40%	35.0
Lauramide DEA	4.0
Soyamide DEA	1.0
Quaternium-70 Hydrolyzed Collagen	2.0
Zinc Pyrithione 40%	4.0
Fragrance, preservative, color	QS
Compound	1000ppm

EXAMPLE 2

Panning of a Phage-Displayed Peptide Library

In this Example, experiments conducted involving panning of a phage-displayed peptide library are described. A commercially available phage peptide library PhD C7C (NEB) was panned against TGFβ-1 and TGFβ-2 according to the manufacturer's instructions. Phage that was still bound to the target after extensive washes, including an acid wash, was used as a template for PCR reactions.

EXAMPLE 3

Construction of a Peptide-BLA Library for TGFβ-1

In this Example, construction of a peptide-BLA library is described. PCR product after one round of phage panning of TGFβ-1 was cloned into pME 30.16 to obtain library pGV02-L. pGV02-L encodes 9-amino acid peptide sequences fused to the N-terminus of *E. cloaceae* ß-lactamase (BLA) with a pIII signal sequence and C-terminal 6XHis tag (*See*, Figure 1). The plasmid also carries a chloramphenicol resistance gene (CAT) as a selectable marker and expression is driven by a *lac* promoter (*Plac*). pME30.16 was digested with *Bbs*I (NEB). To make the inserts the PCR product was used as a template for a PCR reaction using primers with *Bbs*I tails.

Oligos:

ME 190f: GCTATTCAATGTCAGACGAAGACGTCGTTCCTTTCTATTCTCACTCT (SEQ ID NO:35)

ME 190r: GGTGGAGGTTCGGCGTCTTCCCGACTGAATGGCTAT (SEQ ID NO:36)

The cut vector, and stuffer insert (200bp) were ligated overnight at 16 °C in a 1:5 molar ratio respectively, using 10 µl of the DNA mix and 10 ul of Takara solution I ligase. Ligations were purified using Zymo Research DNA clean kit and eluted in 2x µl of water. Then, 5 µl of ligation mix was transformed into 40 µl Top 10 (*E. coli*) electrocompetent cells (Invitrogen), 260 µl SOC was added and the cells were grown forl h at 37 °C. The transformation mix was diluted 1/10 and plated on both LA + 5 ppm CMP and LA + 5 ppm CMP + 0.1 ppm CTX plates, followed by incubation overnight at 37 °C.

EXAMPLE 4

Primary Screen of anti-TGFβ-1-BLA Using Nitrocefin

In this Example, experiments conducted for primary screening of anti-TGFβ-1 are described. Peptides fused to the N-terminus of β-lactamase (BLA) were screened for binding to TGFβ-1, using enzymatic activity on the lactamase substrate nitrocefin as the reporter.

Growth and Assay Procedure

Peptide-BLA fusions were expressed in *E. coli*. The growth medium used was Luria Broth plus 5 mg/mL chloramphenicol. One hundred ml of the growth medium was added to each well of a

sterile Costar 3598 96-well plate (Corning). One clonal colony was picked into each well using a sterile toothpick, and the plate was covered and placed in a humidified shaker/incubator for 40 hours at 37°C. After incubation, 100 mL "B-PER in Phosphate Buffer" (Pierce) was added to each well, and the plate was gently shaken for 30 minutes at room temperature. The resulting cell lysate was diluted 10x in PBS. Then, 100 ml per well of the diluted cell lysate was added to the assay plate (assay plate preparation is described below), which was then covered with a plate sealer (Marsh) and incubated for two hours at room temperature. The assay plate was transferred to a 96-well plate washer (Bio-Tek), where the diluted cell lysate was aspirated and the plate washed once with 100 ml per well, then 3 times with 300 m. PBS plus 0.1% Tween-20 (PBS-T) per well. Then, 200 mL nitrocefin working solution was immediately added to each well. Nitrocefin working solution was prepared just prior to use, by diluting a 100 mg/ml (in DMSO) stock 1000-fold in PBS plus 0.125% n-Octyl-Beta-D-Glucopyranoside (Sigma). After addition of the nitrocefin working solution, the plate was shaken at room temperature for one minute, then read for 5 minutes at 495 nm on a Spectramax plate spectraphotometer (Molecular Devices) in kinetic mode. Total BLA activity in the cell lysate was also be measured by diluting cell lysate

1:100, then combining 20 ml per well of this dilution with 180 ml per well of the nitrocefin working solution.

Assay Plate Preparation

A Costar 3594 assay plate (Corning) was prepared by incubating 100 mL per well of a 1 mg/mL solution of TGFβ-1 (R&D Systems) in 50 mM sodium carbonate, pH 9.6. The plate was covered with a plate sealer (Marsh) and incubated two hours at room temperature. The plate was transferred to a 96-well plate washer (Bio-Tek), where the TGFβ-1 solution was aspirated and the plate washed 3 times with 300 ml PBS-T per well. "Blocker Casein in PBS" (Pierce) was added at 300 mL per well and the plate was incubated overnight at 4 degrees C. "Blocker Casein in PBS" was aspirated and the plate washed 3 times with 300 ml PBS-T per well. The plate was used in the assay immediately following the last wash. For screens in which it was important to distinguish specific TGFβ-1 binders from nonspecific (background) binders, a no-target control plate was prepared, beginning with the addition of "Blocker Casein in PBS", and following the same steps as described.

Data Analysis

In the primary screen, throughput was high priority, and the no-target control plate was left out of the procedure. The BLA activity of the bound material was plotted against the total BLA activity in the sample, and points that lie above a y-axis cutoff were selected as winners. The cutoff was arbitrarily set by the researcher at a value which, for that specific data set, seems likely to separate true binders from the general mass of data points.

In the secondary screen, triplicate samples of the "winners" from the primary screen were grown and assayed together, and a no-target control condition was run in parallel, to distinguish TGFβ-1 binders from nonspecific (background) binders. Wild-type BLA were grown and assayed, to give a measure of the natural "stickiness" of the BLA portion of the fusion molecule. The data were normalized for expression by dividing the TGFβ-1-binding and background-binding activity by the total BLA activity for every well, and the normalized data sets were plotted against each other. Points that lie significantly closer to the "Normalized Bound" axis than the bulk of the data field were selected as winners. Significance was determined by a visual assessment of each point's location in the data field, and the size of its error bars. The results of these experiments are provided in Figure 3.

EXAMPLE 5

Secondary Screen of Anti-TGFβ-1-BLA Using Nitrocefin

This Example describes secondary screening methods used to analyze anti-TGFβ-1 peptides. Individual clones were picked and grown up in 5 ml LB + 5ppm CMP overnight at 37 °C. The cell pastes were then treated with 125 μ of B-PER reagent (Pierce) for 30 min with slow mixing. COSTAR plates (96-well) were coated with 0.1 μg (100 μl of 1 μg/ml) TGFβ-1, carrier-free (R&D Systems) with gentle rocking at 4 °C overnight, followed by blocking with Superblock blocking buffer (Pierce) for several hours at room temperature. Then, 100 μl B-Per treated supernatant from individual clones from pGV02-L were added to the TGFβ-1 coated plates. After one hour, plates were washed six times with PBS, 0.05% TWEEN®-20 and 200 μl of nitrocefin assay buffer containing 0.1 mg/ml nitrocefin (Oxoid) was added to measure residual bound beta-lactamase activity, using Abs_{490}/min. Control wells contained pCB04 (*See,* Figure 1C) beta-lactamase as a control. Out of 180 clones, 3 showed a positive signal. These clones were sequenced, and the results are provided in Table 1, where the first column is the name of the peptide, the second column is the nucleotide sequence and the third column is the amino acid sequence of the peptide:

Table 1. Clones Sequenced (TGFβ-1)

Name	Nucleotide Sequence	Amino Acid Sequence
1A8	TGTGTGACTACTGATTGGATTGAGTGC (SEQ ID No:1)	CVTTDWIEC (SEQ I D NO:2)
1E11	TGTTACTATTCGCAATTCCACTAGTCG (SEQ ID NO:3)	CYYSQFHQS (SEQ ID NO:4)
1A12	TGTCCGACGCTGTGGACGCATATGTGCG (SEQ ID NO:5)	CPTLWTHMC (SEQ ID NO:6)

EXAMPLE 6

Purification of Three Sequenced Clones

In this Example, experiments involving purification of the BLA-peptide fusion proteins of the three clones in Example 5 are described. These fusion proteins were expressed in *E. coli* (TOP10; Invitrogen) in 15-ml shake flasks in the presence of 5 ppm CMP and 0.1 ppm cefotoxime (CTX) antibiotic at 37 °C overnight. A commercially available purification kit (Insect RoboPop Ni/NTA His Bind Purification Kit, Novagen) was used to purify these peptide BLA fusions according to the manufacturer's instructions.

EXAMPLE 7

Creation of TGFβ-1/BBI Binding Peptides

In this Example, experiments conducted to create TGFβ-1/BBI binding peptides are described. TGFβ-1 binding peptides, specifically, binding peptides with inserted peptides as disclosed herein, were introduced into the BBI trypsin inhibitory loop or chymotrypsin inhibitory loop using the QUIKCHANGE® II XL Site-Directed Mutagenesis Kit (Stratagene). The mutagenesis reaction was performed essentially as described in the technical manual provided by the manufacturer (Stratagene). The vector, p2JM103-DNNDPI-BBI, was used as a template (see Figure 1B). This *B. subtilis* expression vector has the BCE103 cellulase fused to BBI with a cleavable linker between the two domains. Transcription is driven by the *B. subtilis aprE* promoter and the *aprE* signal sequence is included for secretion of the fusion protein. The vector was constructed from pUC19 for replication and selection in *E. coli* and also had an inserted chloramphenicol acetyltransferase gene for selection in *B. subtilis*. In the mutagenesis reaction, approximately 200 ng of the plasmid was used with 50 pmol of each of the oligonucleotide primers. In various experiments, the following primers were used:

1A8 (2^{nd} loop)
CAAAAGCTGCGCATGTGTTACTACAGATTGGATCGAATGTTTTTGCGTCGACATCACG G (SEQ ID NO:37)
and
ACGCAAAAACATTCGATCCAATCTGTAGTAACACATGCGCAGCTTTTGCATGCACTAT G (SEQ ID NO:38)

1A12 (2^{nd} loop)
CAAAAGCTGTGCCTGCCCAACACTTTGGACTCATATGTGTTTTTGCGTCGACATCACG GAC (SEQ ID NO:39)
and
ACGCAAAAACACATATGAGTCCAAAGTGTTGGGCAGGCACAGCTTTTGCATGCACTA TGAC (SEQ ID NO:40)

1E11 (2^{nd} loop)
CAAAAGCTGCGCATGTTACTACTCTCAATTCCACCAATGTTTTTGCGTCGACATCACG G (SEQ ID NO:41)
and
ACGCAAAAACATTGGTGGAATTGAGAGTAGTAACATGCGCAGCTTTTGCATGCACTA TG (SEQ ID NO:42)

TGFps1 (2^{nd} loop)
CAAAAGCTGTCTTTGTCCGGAAAACGATAACGTTTCTCCTTGTAATTGCGTCGACATC ACGGACTTCTG (SEQ ID NO:43)
and
TGTCGACGCAATTACAAGGAGAAACGTTATCGTTTTCCGGACAAAGACAGCTTTTGC ATGCACTATGAC (SEQ ID NO:44)

The reaction mixture was held at approximately 97 °C for 3 minutes and then held at approximately 50 °C until polymerase was added to each tube. The reaction mixture was then be cycled at 68 °C for 6 minutes, 95 °C for 50 seconds and 55 °C for 50 seconds for 22 times. After cycling, the reaction mixture was held at 68 °C for 20 minutes and then cooled to 4 °C before continuing on with the protocol.

After *Dpn*I digestion, an aliquot of the reaction mixture was used to transform XL10 Gold cells, colonies picked, plasmids isolated (QIAprep Spin Miniprep Kit, Qiagen), and the variants detected by restriction digests. Positives were checked for the correct sequence by DNA sequencing.

EXAMPLE 8

BIAcore™ Binding Analysis of Anti-TGFβ-1 Peptides

In this Example, experiments conducted to assess the affinities of the peptides for TGFβ-1 are described. Affinities of the peptides for TGFβ-1 were measured using a BIAcore™-3000 surface plasmon resonance system (Biacore). A CM5 sensor chip was conditioned with 50 mM NaOH, 0.1% HCl, 0.1% SDS, and 0.08% H_3PO_4, and activated for covalent coupling of FGF-5 using *N*-ethyl-*N*'-(3-dimethylaminopropyl)-carbodiimide hydrochloride (EDC) and *N*-hydroxysuccinimide (NHS) according to the supplier's instructions (Biacore). Human TGFβ-2, (PeproTech) was diluted to 5 μg/ml in 10 mM acetic acid, pH 4.0 and injected at a flow rate of 2 μl/min to achieve approximately 1000 to 2000 response units (RU) of coupled protein. An additional solution of EDC and NHS were injected to improve baseline stability and a solution of 1 M ethanolamine injected as a blocking agent. The reference lane was activated with EDC and NHS and blocked with ethanolamine.

Peptides were synthesized using standard FMOC chemistry, purified by reverse phase HPLC to >95% purity (SynPep), and stored at 10 mg/ml in either water or 10% DMSO. For kinetic measurements, three-fold or four-fold serial diluted peptides in HBS-EP buffer, 0.01 M HEPES pH 7.4, 0.15 M NaCl, 3 mM EDTA, 0.005% Surfactant P20 (Biacore), were injected at 25°C at a flow rate of 50 μl/min. Serially diluted DMSO samples and buffer samples were also injected, to allow for background subtraction. Two 120 sec injections of 20 mM HCl were used between sample injections for regeneration. Kinetic parameters k_{on}, (M^{-1} sec^{-1}), k_{off} (sec^{-1}) and K_D (M) were calculated using software programs, Scrubber version 1.1f, BIAevaluation 3.1, and Clamp99 version 3.30.

EXAMPLE 9

Panning of a Phage Displayed Peptide Library

In this Example, experiments conducted in panning a phage displayed peptide library for TGFβ-2 are described. A commercially available phage peptide library PhD C7C (NEB) was panned against TGFβ-2 according to the manufacturer's instructions. Phage that was still bound to the target after extensive washes, including an acid wash, was used as a template for PCR amplification.

EXAMPLE 10

Construction of a Peptide-BLA Library for TGFβ-2

PCR product after one round of phage panning was cloned into pME 30.16 (*See,* Figure 1) to obtain library pGV03-L. pGV03-L encodes 9-amino acid peptide sequences fused to the N-terminus of *E. cloaceae* ß-lactamase (BLA) with a pIII signal sequence and C-terminal 6XHis tag. The plasmid also carries a chloramphenicol resistance gene (CAT) as a selectable marker and expression is driven by a lac promoter (Plac). Library pGV03-L was constructed using a BLA vector, pME30.16. pME30.16 was digested with *Bbs*I (NEB). To make the inserts the PCR product was used as a template for a PCR reaction using primers with *Bbs*I tails. The same oligonucleotides as used in Example 3 were used in these experiments (*i.e.,* ME190 f and ME 190r).

The cut vector and stuffer insert (200bp) were ligated overnight at 16 °C in a 1:5 molar ratio respectively using 10 µl of the DNA mix and 10 ul of Takara solution I ligase. Ligations were purified using Zymo Research DNA clean kit and eluted in 2x 8ul of water. 5 µl of ligation mix was transformed into 40 µl Top 10 electrocompetent cells (Invitrogen), 260 µl SOC was added and the cells grown forl h at 37 °C. The transformation mix was diluted 1/10 and plated on both LA + 5 ppm CMP and LA + 5 ppm CMP + 0.1 ppm CTX plates, followed by incubation overnight at
37 °C.

EXAMPLE 11

Primary Screen of Anti-TGFβ-2 -BLA using Nitrocefin

In this Example, experiments involving primary screening of anti-TGFβ-2-BLA are described. Peptides fused to the N-terminus of β-lactamase (BLA) were screened for binding to TGFβ-2, using enzymatic activity on the lactamase substrate nitrocefin as the reporter. The

growth and assay procedures, assay plate preparation methods and data analysis used in these experiments is the same as that described in Example 4 above for TGFβ-1, the only difference being that TGFβ-2 was used instead of TGFβ-1. The results are shown in Figure 4.

EXAMPLE 12

Secondary Screen of Anti-TGFβ-2 BLA using Nitrocefin

In this Example, experiments conducted in a secondary screen of anti-TGFβ-2 are described. The methods used in these experiments are the same as described above in Example 5, with the exception being that TGFβ-2 was used instead of TGFβ-1. As with Example 5, controls contained pCB04 beta-lactamase (*See*, Figure 1C) as a control. Out of 180 clones, 5 showed a positive signal. These clones were sequenced, and results from sequencing are presented in Table 2, below.

Table 2. Clones Sequenced (TGFβ-2)

Name	Nucleotide Sequence	Amino Acid Sequence
1A3	TGTCATGGGTATGATCGGGCGCCTTGC (SEQ ID NO:7)	CHGYDRAPC (SEQ ID NO:8)
1 E 5	TGTTTTGCCCCCGCTGACCAGGCGTGC (SEQ ID NO:9)	CFAPADQAC (SEQ ID NO:10)
1G9	TGTATTCCATCCCGTTTCATAACTTGC (SEQ ID NO:11)	CIPSRFITC (SEQ ID NO:12)
1A12	TGTCATGGGCATACTAAGCTGGCTTGC (SEQ ID NO:12)	CHGHTKLAC (SEQ ID NO:14)
1G4	TGTAATGGGAAGTCGAAGCTGGCTTGC (SEQ ID NO:13)	CNGKSKLAC (SEQ ID NO:16)

EXAMPLE 13

Purification of Sequenced Clones

The BLA-peptide fusion proteins of the 5 TGFβ-2 clones were expressed in *E. coli* and purified as described above in Example 6. in 15-mL shake flasks in the presence of 5 ppm CMP and 0.1 ppm cefotoxime (CTX) antibiotic at 37 °C overnight. A commercially available purification kit (Insect RoboPop Ni/NTA His Bind Purification Kit, Novagen) was used to purify the 5 peptide BLA fusions according to the manufacturers instructions.

EXAMPLE 14

Creation of TGFβ-2/BBI Binding Peptides

These experiments were conducted in the same manner as described in Example 7, with the only exception being that TGFβ-2, rather than TGFβ-1 was used.

EXAMPLE 15

BIAcore™ Binding Analysis: Anti- TGFβ-2 Peptides

As with the above Examples 13 and 14, the methods used in these experiments are the same as those used for TGFβ-1 (*i.e.*, Example 8, here). As above, the only exception is that TGFβ-2, rather than TGFβ-1 was used.

EXAMPLE 16

Cell-Based Assay Using HT-2 Cells

In this Example, experiments conducted to determine the biological activity of the BLA-peptide fusion proteins, as well as the BBI/BCE-peptide fusion proteins are described . The peptides tested are included in the Table of Peptides provided above. The biological activity of these peptide fusion proteins were measured in a proliferation bioassay, using HT-2 cells. The HT-2 cell line is a cloned murine T-helper, factor-dependent cell line (*See*, Watson, J. Exp. Med., 150:1510 [1979]). This assay system is well-defined and used by R & D Systems as a means to measure the activity of cytokines and growth factors. The cells were typically grown in RPMI-1640 medium supplemented with 10% heat-inactivated FBS, 50 μM β-mercaptoethanol, 2 mM L-glutamine, 100 Units/ml penicillin, 100 μg.ml streptomycin, and 10 ng/ml rhIL-2. The Assay Medium used was RPMI-1640, supplemented with 10% heat-inactivated FBS, 50 μM β-mercaptoethanol, 2 mM L-glutamine, 100 Units/ml penicillin, and 100 μg/ml streptomycin.

Cells were grown up and then incubated with the TGFβ-1 peptide fusion proteins (*i.e.*, BLA-TGFβ-1, or BBI/BCE-TGFβ-1). Cells were tested in the log growth phase, harvested and washed three times with RPMI. The standards and samples were diluted to working concentrations in PBS and 1.0 mg/ml BSA. Prior to use, the microtiter plates were pre-blocked with PBS and 1% BSA for two hours at room temperature.

In order to measure the ability of the peptide fusions to "neutralize" or antagonize the bioactivity of the TGFβ-1 on HT-2 cells, constant concentrations of TGFβ-1 were incubated with various concentrations of the peptide for either 30 minutes or 1 hour at room temperature or 37°C in a 96-well microtiter plate. Following this preincubation period, 50 μl of HT-2 cells ($2x10^5$ cells/ml in Assay Medium) were added to each well. The assay mixture was incubated at 37°C for approximately 48 hours in a 5% CO_2 incubator with humidity. Then, 3H-thymidine (10

μl/well of 25 μCi/ml ^{3}H-thymidine working stock in Assay Medium) was added during the last 4 hours of incubation. The cells were subsequently harvested onto glass fiber filters using a cell harvestor, and the 3H-thymidine incorporated into DNA was determined. The dose response was then determined for the various concentrations of TGFβ-1. The results for TGFβ-1 indicated that there was no activity for the BLA-TGFβ-1 fusions, while there was some activity for one of the BBI/BCE-peptide fusions. Some results obtained are provided in the Table of Peptides (*See*, above). The same assay is used with other peptide fusions, in particular TGFβ-2 fusions.

EXAMPLE 17

Bio-Veris Assays

In this Example, binding assays using Bio-Veris's protocols are described. This assay system was optimized by testing several of the reagents at different concentrations to determine maximum signal:background ratio.

The assay was conducted as follows. First, the target (*e.g.*, TGFβ-1) was biotinylated using EZ-Link Sulfo-NHS-Biotin (Pierce) and the protocol provided by the manufacturer. The receptor (TGF-b sRII) was then tagged using BV-tag (BioVeris), using the BioVeris labeling protocol. Diluted stock solutions of each reagent above (at optimized concentrations to provide the best signal:background ratio) were prepared in PBS with 0.05% TWEEN®-80 to the following concentrations: bTGF-β1: 100 ng/mL and BV-TGFβ sRII: 500 ng/mL.

Then, 50 μl of biotinylated target were added to each well of a 96 well round bottom polypropylene plate (Costar 3365). Next, 50 μl of the construct to be tested (serially diluted 6x (1000 nM→0) in PBS + 0.05% TWEEN®-80, to provide a range of activity) were added to the wells. Then, 50 μl BV-TGF-b sRII diluted in PBS + 0.05% TWEEN®-80 was added to the wells. The plate was incubated with gentle shaking (being careful to avoid well to well transfer) for 1 hour at room temperature. Following incubation, 50 μl streptavidin microbeads (Dynal) (0.2 mg/mL diluted in PBS + 0.05% TWEEN®-80) were added to the wells The plates were then incubated for 30 minutes at room temperature, with gentle shaking. The total in the wells was then brought up to 250 μl/well with PBS+0.05% TWEEN®-80. The plate was then read on a BioVeris M Series 384 machine, using the default program. Some results obtained are provided in the Table of Peptides (*See*, above).

EXAMPLE 18

In Vivo and *Ex Vivo* Assays

In this Example, *in vivo* assays to evaluate the constructs produced above are described. In particular, *in vivo* assays are performed to test each of the constructs for hair care, as known in the art (*See e.g.*, Tobin *et al.*, J. Invest. Dermatol., 120:895 [2003]).

In additional embodiments, methods such as those that assess the influence of growth factors on hair growth find use in the present invention. Such methods are known in the art and include, but are not limited to the Philpott assay system (*See e.g.*, Philpott *et al.*, J. Dermatol. Sci., 7 (Suppl.):S55-72 [1994]).

Having described the preferred embodiments of the present invention, it will appear to those ordinarily skilled in the art that various modifications may be made to the disclosed embodiments, and that such modifications are intended to be within the scope of the present invention.

One skilled in the art would readily appreciate that the present invention is well adapted to carry out the objects and obtain the ends and advantages mentioned, as well as those inherent therein. The molecular complexes and the methods, procedures, treatments, molecules, specific compounds described herein are presently representative of preferred embodiments, are exemplary, and are not intended as limitations on the scope of the invention. It will be readily apparent to one skilled in the art that varying substitutions and modifications may be made to the invention disclosed herein without departing from the scope and spirit of the invention.

All patents and publications mentioned in the specification are indicative of the levels of those skilled in the art to which the invention pertains. All patents and publications are herein incorporated by reference to the same extent as if each individual publication was specifically and individually indicated to be incorporated by reference.

The invention illustratively described herein suitably may be practiced in the absence of any element or elements, limitation or limitations which is not specifically disclosed herein. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention that in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the following claims.

The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.